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EXPRESS PASSENGER ENGINE, LANCASHIRE AND YORKSHIRE RAILWAY.

WE illustrate a new type of locomotive designed by Mr. Barton Wright, and built by the Vulcan Foundry Company, Newton-le-Willows, Lancashire. The following are the particulars of these fine engines:

	ft.	in.
Boiler—		
Diameter of barrel, outside, at fire-box end.	4	4
Length of barrel	10	3
Thickness of plates, Yorkshire iron	0	0½
Fire-box shell—		
Length outside	6	0
Breadth outside at bottom	4	1
Depth from C line at front	4	8
Depth from C line at back	3	6
Copper fire-box—		
Length of fire-box inside, top	5	0¾
Length of fire-box inside, bottom	5	4⅝
Breadth of fire-box inside, top	3	8
Breadth of fire-box inside, bottom	3	6
Depth at front end	5	4¾
Depth at back end	4	2¾
Tubes—		
Material, iron; number, 192.		
Diameter outside	0	1¾
Length between tube plates	10	7⅝
Heating Surface—	sq. ft.	
Fire-box	90·5	
Tubes	935·5	
	1026·0	
Grate area	19·25	
Cylinders—	ft.	in.
Inside diameter of cylinders	1	5½
Stroke of piston	2	2
Length of ports	1	3
Width of steam ports	0	1½
Width of exhaust ports	0	3
Center to center of cylinders	2	4
Center to center of valve spindles	0	3¾
Eccentrics—		
Throw	0	6½
Diameter	1	4
Rods—		
Length of eccentric rods	4	10
Length of connecting rods	6	2
Wheels—		
Diameter of coupled wheels on tread	6	0
Diameter of bogie wheels on tread	3	7½
Thickness of all tires when finished	0	3
Width of all tires when finished	0	5½
Wheel base—		
From center to center of bogie axles	5	6
From center of bogie to driving axle	9	8½
From center of driving to trailing axle	8	7
Total wheel base	21	0½
Axles—best mild crucible cast steel—		
Bogie, diameter of journals	0	5½
Bogie, length of journals	0	8
Driving, diameter of crank pin journals	0	7½
Driving, length of crank pin journals.	0	4
Driving, diameter of journals	0	7½
Driving, length of journals	0	7
Trailing, diameter of journals	0	7½
Trailing, length of journals	0	7

Weight of engine in working order—

	tons.	cwt.	qrs.	lb.
Bogie wheels	12	18	0	0
Driving wheels	14	13	2	0
Trailing wheels	14	4	0	0
Total	41	15	2	0

Weight of engine empty—

	tons.	cwt.	qrs.	lb.
Bogie wheels	12	16	2	0
Driving wheels	13	10	0	0
Trailing wheels	13	0	0	0
Total	39	6	2	0

These engines are employed in working the main line fast traffic, and are a complete success.—*The Engineer.*

ENGLISH AND AMERICAN LOCOMOTIVES.

To the Editor of Engineering:

Mr. Burnett, in his first communication to you, condemned the American engine axle and commended the English axle as being much the best. Now the English straight axle, whether of iron or steel, requires a great deal of special hammer work put upon it. The central portion has to be reduced below the collars and bosses for the wheels; it has to be heated and reheated for this purpose, and there is considerable loss and waste in the furnace, and through cutting and paring cross ends; and however carefully forged, there is a good deal of waste in the lathe, cutting out for the journals and collars. Now the American axle is cut from a straight bar forged or rolled.

There is little waste in cutting it to length, and putting it through a straightening mill; there is only a slight scraping taken off it in the lathe to true it up for the wheels, journals, and collars, the latter being shrunk on instead of being solid as in the English axle. In the case of the driving axle the center part is turned a little larger than the portion for the wheels and journals. The eccentrics solid are first pushed on, then the collars are shrunk on, and then the wheels, the end contact of the axle brasses being made between the bosses of the wheels and the collars.

Now as compared with the English axle we have here:

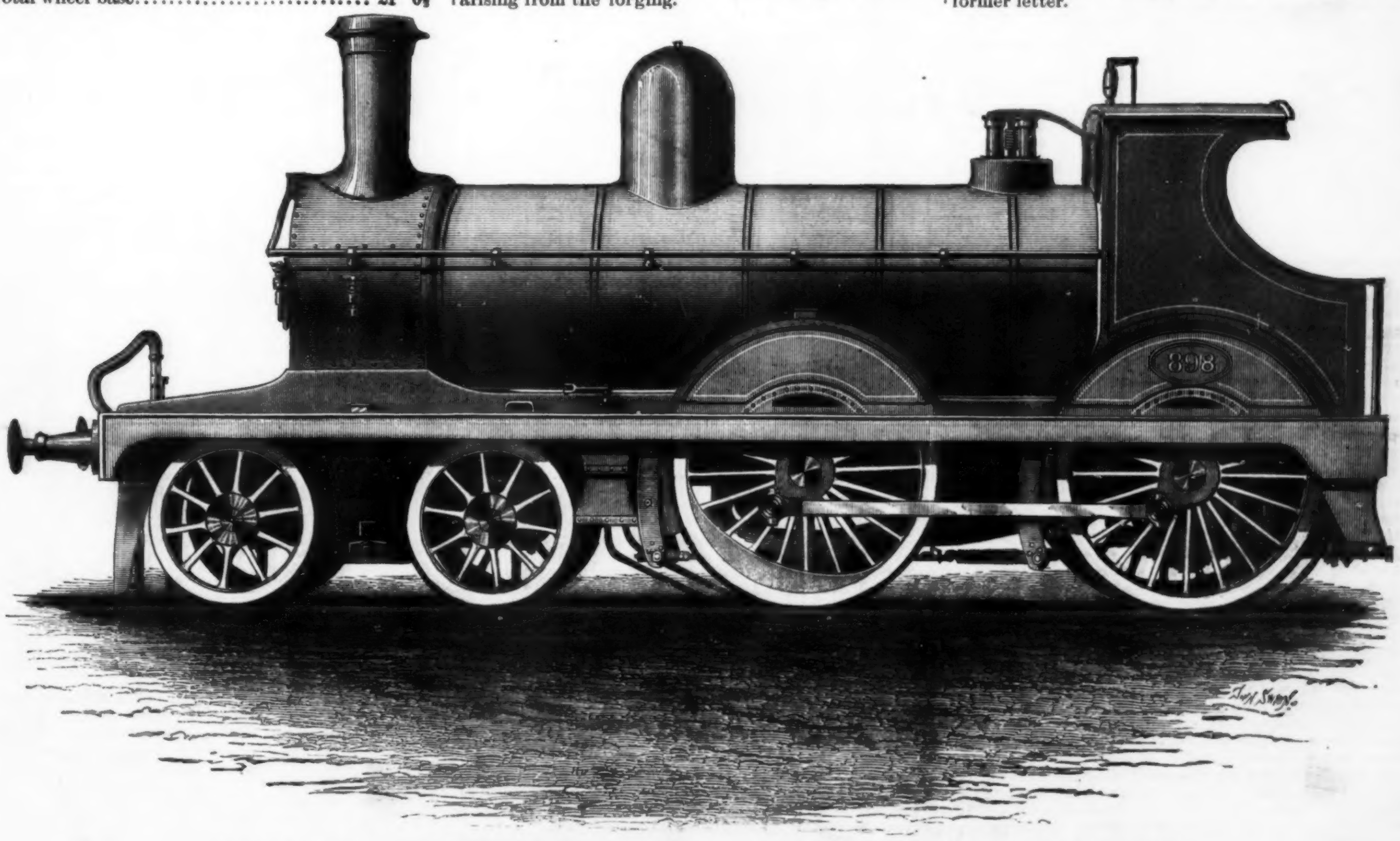
1. No distortion of fiber or irregularity of structure arising from the forging.

2. No sharp corners to weaken or start a fracture when a heavy blow or strain is thrown on the wheels.

3. Most perfect simplicity and economy; and this simplicity and economy is carried throughout every detail of the American engine. Some of your correspondents have said that any country blacksmith could repair it, and surely this is the very highest commendation. Scattered over some 130,000 miles of railroads of this great continent, climbing huge mountains, running over the most miserable roads—many without ballast—crawling over rickety wooden bridges, or turning square round a street corner on the overhead railroads in New York, there is no other engine that could adapt itself to this work; often ditched by washouts in wild, unsettled districts, there is no engine which can be so quickly set on its legs again. Can we wonder our colonists desire it? A machine in which there is not a pound's weight of material more than is required, not a cent's worth more cost than is necessary; there is no other engine which has such steaming qualities or can take such heavy loads, and this engine is a racer, too, as Mr. Burnett describes it, coming thundering along at more than seventy miles an hour with the brave boys strapped on, coolly taking their diagrams. We hold our breath, and say on what English engine would you like to do this, when, most astonishing, Mr. Burnett trots out a Brighton engine, and with his pencil and paper and a few figures runs the American engine off the road.

In my former letter I asked what would American engineers gain by using the plate frames. Let me ask what American railroad companies would lose by using the English crank axle and the English wheel; and taking the last year's returns of what I consider the model railroad of the world, the Pennsylvania Railroad would, according to their mileage, had they used the English locomotive, have broken from 170 to 200 crank axles last year. That is at 200,000 miles per crank. Figure up the forges, steam hammers, slotting machines, and crank axle lathes required to turn out all their crank axles. This same railway last year turned out of their foundry upward of 100,000 cast iron wheels, and they saved nearly 60,000*l.* sterling by making them at their own works. Count up the regiment of forges, lathes, and slotting machines to turn out 100,000 English wheels in a year, and when to all this you add the copper fireboxes and brass tubes required by the English engine, you will get an idea of not only the loss, but what would be the ruin of the American railways—the adoption of the English locomotive engine.

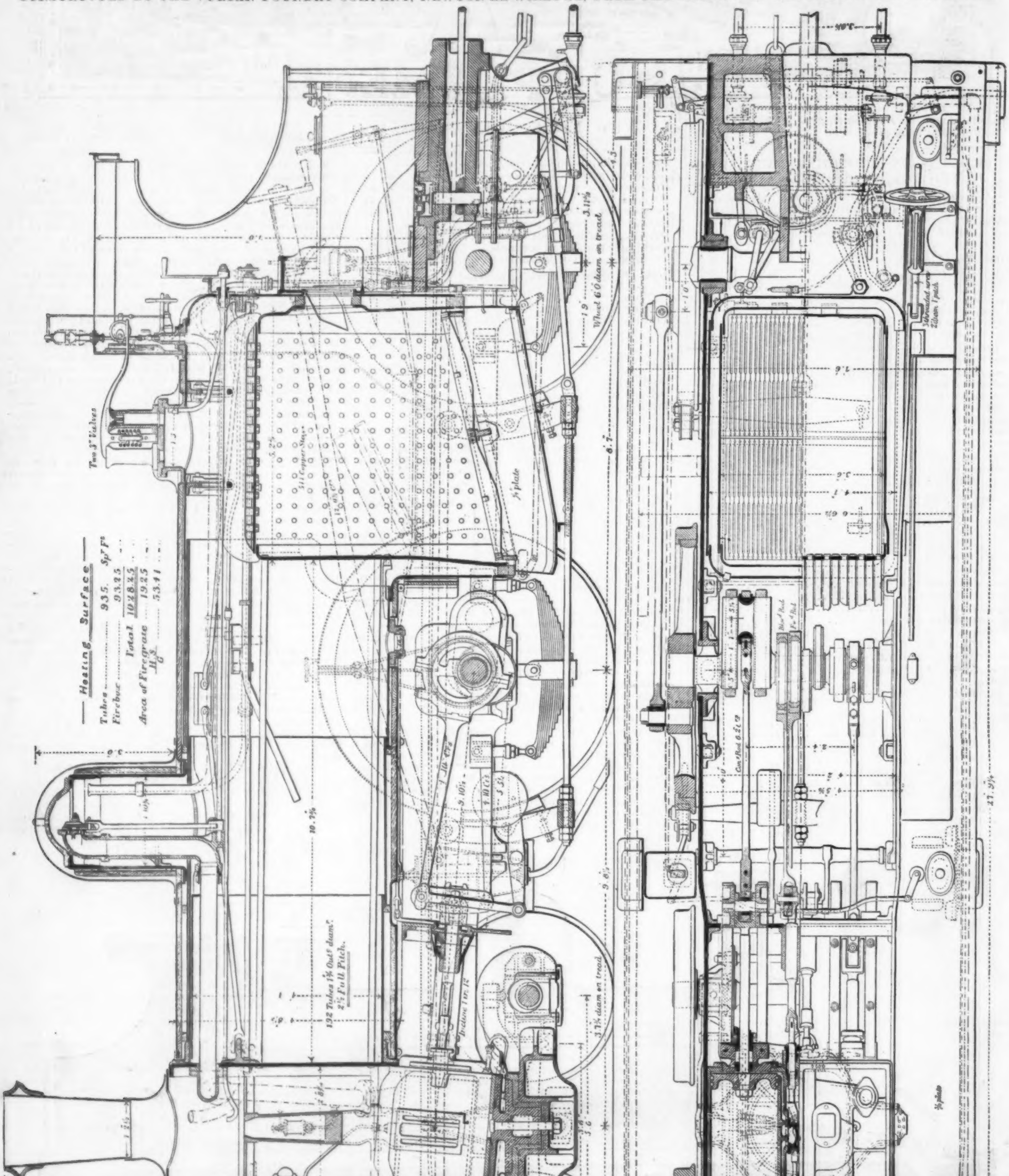
I was quite willing to accept Mr. Burnett's estimate that the American engine was 400*l.* cheaper than the English engine, but since he explains away that estimate, I must place the different details of the engines opposite to one another, and leave engineers to judge for themselves as to their relative expense, my estimate being that the American engine, say with 16 in. cylinders, would cost even less than what I mentioned in my former letter.



ENGLISH EXPRESS ENGINE, LANCASHIRE AND YORKSHIRE RAILWAY.

EXPRESS BOGIE ENGINE, LANCASHIRE AND YORKSHIRE RAILWAY.

CONSTRUCTED BY THE VULCAN FOUNDRY COMPANY, NEWTON-LE-WILLOWS, FROM THE DESIGNS OF MR. BARTON WRIGHT, M.I.C.E.



English Engine.	*American Engine.*
Boiler best Yorkshire iron.	Open hearth steel.
Copper fireboxes ½in. thick	Steel firebox $\frac{5}{16}$ in. thick.
Copper stays.	" stays.
Brass tubes.	Iron tubes.
Crank-axle.	Straight bar axle.
Straight axles forged.	" " axles.
Plate frames.	Bar frames.
Steel horn blocks.	
Wrought-iron wheel centers drivers.	Cast iron centers.
Crucible steel tires.	Open hearth steel tires for drivers.
Wrought iron centers leading.	Cast iron wheels.
Crucible steel tires.	Leaders in bogie.

I conclude this portion of my letter by saying that in my opinion no more complicated, wasteful, and unscientific form of locomotive engine could be devised than the English engine, and no more simple, economical, and scientific than the American engine, and my advice to the English railway companies would be to copy it and to duplicate it as soon as possible.

Now Mr. Burnett asks for results. Well, take our greatest colony, the one nearest our doors, the most loyal, a country of boundless undeveloped wealth, the colony with the greatest railway mileage, and whose very existence and future development depend on the extension of railways and cheap ways of working them, a country where railways have been built with English capital. Does Canada use the English locomotive or the English wheel? and if not, then, why not? Surely the example of Canada, Australia, and New Zealand refusing to use the English engines should be enough for Mr. Burnett.

And now in answer to various anonymous correspondents who have attacked me as to my motives in writing on this question, I may say that for the last fifteen years, in letters to the *Times* and in discussions and papers at the Institution of Civil Engineers, I have shown the progress made by American engineers and advised the adoption of their improvements in England, and if those who blame me will look back to papers by Fox "On the Pennsylvania Railroad," Galton "On the Appliances at the Centennial Exhibition at Philadelphia, 1876," my own paper "On Steel for Fireboxes," and correspondence with Mr. Forrest "On American Bridges," they will find I have sought to inform and warn English engineers as to the great progress of American engineering.

Captain Galton, in closing the discussion on his paper, said: "I went to Philadelphia as a juror. I took notice of what I saw, and I embodied it in this paper, and every one who has spoken on this subject has brought in a bill of indictment against me for speaking in favor of American inventions." Surely it was patriotic in me to have lifted my voice for the last fifteen years in warning England and informing her about American improvements, but neither my voice nor the voices of others who have spoken, as I have done, have been listened to, and now the Nemesis has come.

Macaulay saw in the far distant future the descendant of the aboriginal New Zealander surveying the ruins of London Bridge, and moralizing on the downfall of the great nation that once lived on the banks of the Thames. But had Macaulay lived a few years longer, he would have seen England, a free trade country, still standing in the front rank as the greatest manufacturing country of the world, with the cheapest labor, the cheapest material, the cheapest money; while an Australian engineer, condemning all the English bridges designed for his country, and taking the money he had borrowed from England to a country where labor, material, and money were the highest in the world, to buy in this protectionist country, America, a cheaper and a better bridge. To my mind one of the saddest things in connection with this matter was to see able men referring to it, whether at first or second hand, as being cheap and nasty.

There is no doubt that in the old times many an English victory was obtained by men not knowing when they were beaten, but brute strength will not win the battle in these days of science and precision. We must excel the victor in his arts, or copy him. Has England the inventive skill to beat America? What improvements has England effected during the last twenty-five years in railways, and what has America done? Will England copy American inventions and ideas? Certainly not till she is compelled. Look at the first street railway in London; at Mr. Alport's attempt to introduce the American carriages on the Midland Railway.

Take the last case, perhaps one of the very worst, the automatic brake. Now, in my opinion, there was only one good brake in the market, and this was so much the best that there was not even a good second to it; but if reasonable terms could not have been made for its use, then all the companies should have united and adopted the next best. What is the case to-day? How many brakes are there in England? In America there is practically but one brake, and uniformity is universal, but how can there be interchangeability when there is diversity of apparatus and systems as in England? Consequence is the railways have to pay for it, and when the system is adopted on goods trains, as it is being done here, it will cost the railways perhaps a million to get the best brake, the one that should have been adopted at the first.

JOHN FERNIE, M.I.C.E., England.

Dundaff, Pa., U. S. A., June 14, 1886.

[BRADSTREET'S.]

THE CANADIAN PACIFIC RAILWAY.

ONE often hears in the Dominion the remark that the people of the United States have no conception of what the Canadian Pacific Railway is. In a great measure this is true. That enterprise, in its principal features, has now been carried to a successful conclusion.

From the present eastern terminus various lines afford connection with New York, Boston, Portland, St. John and Halifax, while the creation of a "short route" from Montreal to Halifax is fully determined on, and a question of only a comparatively short time. A new line, transcontinental in fact as well as in name, is thus about to be opened for business. As a physical achievement the construction of the Canadian Pacific takes high rank among the noteworthy instances of railway building. From a commercial point of view the outlook is more encouraging than any one ventured to predict five, or even three, years ago. And as a means of strengthening the British empire the value of the road is unquestionably great.

The progress, condition, and prospects of this extensive undertaking are interesting from many points of view. For the present it will suffice to look into its financial status. This, it should be understood, does not involve necessarily an investigation of the finances of the Dominion of Canada, although, without doubt, the national treasury would be much better off if the railroad had never been thought of. With money collected from the people of Canada through taxes imposed by the government, with other money borrowed of the government and of capitalists, and with still other money directly subscribed, the Canadian Pacific Company has within about five years constructed, or acquired by purchase or otherwise, 4,338 miles of line, and has placed upon it a first-class equipment. Some 700 miles of this total was built by the government and given to the company outright, as if it were so much cash.

The questions of immediate interest now are: How much has this property cost? where, in detail, has the money come from? what are the fixed charges upon the revenue of the system? and do the earnings promise to be sufficient to meet these fixed charges and to yield dividends to the shareholders? Comparatively full information under all of these heads has been furnished from time to time in the annual reports of the directors. The statement made to the shareholders at the recent meeting in Montreal was less complete in some respects than last year's report. In certain particulars, however, the situation was clearly set forth.

It will be remembered that in 1884, when the company's means were on the point of giving out, the government loaned it $30,000,000. Predictions were frequent that no part of this money would ever be returned. As a matter of fact, however, two-thirds of it is to be repaid. When, in the spring of 1885, the company found it impossible to secure money by the sale of stock, Parliament authorized the issue of $35,000,000 worth of 5 per cent. first mortgage bonds, in lieu of that amount of shares. These securities have now all been marketed. The last lot of $20,000,000 was recently sold by Baring Brothers & Co. at 104. The price for the full issue was very near par.

The placing of this great loan on so favorable terms is naturally gratifying to the corporation. It affords a good indication of its financial strength. From the proceeds of this issue the company, on the 1st of May, paid to the government $10,000,000, and on July 1 will hand over as much more, thereby repaying $20,000,000 of the loan secured in 1884. In satisfaction of the remaining $10,000,000 of indebtedness incurred at that time, the government will take back from the company about 7,000,000 acres of the 25,000,000 acres of land originally granted, at $1.50 per acre. This, of course, amounts practically to a free gift of the $10,000,000 to the road. The result is precisely the same as if the government had never granted the land, but had presented the corporation with the $10,000,000 in the first instance.

There was at the outset a direct subsidy of $25,000,000, while the cost of that part of the line constructed by the government and given to the company free, 713 miles in all, is estimated at $35,000,000. It therefore appears that the direct investment of the government in the enterprise will stand, after the proposed arrangement is completed, substantially as follows:

Original subsidy	$25,000,000
Cost of road built by the government	35,000,000
Gift in lieu of land	10,000,000
Total in money	$70,000,000
Land grant as reduced, acres	18,000,000

After the cancellation of the government loan in full, July 1, the capitalization of the road will be as follows:

Stock	$65,000,000
First mortgage bonds	35,000,000
Leased lines capitalized at 5 per cent.	21,560,680
Other securities	5,323,333
Total capital	$126,884,013

Of this sum, fixed liabilities obviously amount to $61,884,013. The interest rate, including rentals, is 5 per cent., except on $1,823,333, which bears 6 per cent., and the annual fixed charges of every description stand at $3,110,434. The stock is guaranteed 3 per cent. dividends for 7½ years from date, to cover which sufficient cash is on deposit with the government.

The above fixed charge, it is important to observe, is very small in comparison with the drains on the American Pacific roads. It may be comparatively easy to clear the interest on $62,000,000, but quite impossible to come out square if twice as much net income must be realized. Herein lies one of the greatest advantages derived by the investors in the Canadian Pacific from the generosity of the taxpayers. If the government had not given the company outright the $70,000,000 above mentioned, the showing for profits would be very different.

As matters stand the directors of the company are fully justified in predicting favorable results from the operation of the line. There appears to be no longer much doubt of the ability of the road to earn its interest. The only question is whether the Lake Superior and Rocky Mountains sections are going to prove a source of net income or some expense. Upon this point the managers of the road borrow no trouble. The gross receipts of the calendar and fiscal year 1885 amounted to $8,368,493, and the expenses of every description to $5,143,276, leaving a net income of $3,225,216, or over $100,000 in excess of the annual charges as above outlined. So far as the transportation of construction material is concerned, it is included alike in the receipts and expenses shown in the table. The outlook for traffic, it should be added, surpasses the most sanguine expectations of the promoters of the enterprise.

The Canadian Pacific Railway enterprise reaches much further than the mere construction and operation of the road whose financial condition we have described. This link in the great chain extends nearly, but not quite, across the American continent, connecting Montreal on the St. Lawrence River with seaports on an inlet of the Pacific Ocean. Beyond the western terminus the scheme looks to the establishment of steamship connections with Japan, China, Australia, and India. At the east, again, a short route is ultimately to be constructed between Montreal and Halifax, and fast steamship service is to be put on between Halifax and Liverpool.

A roundabout railroad, the Intercolonial, is now in operation between Montreal and Halifax *via* Quebec. There is thus already a transcontinental road on British soil; and the starting of the steamers on the line just spoken of will establish a great and permanent transportation route under British control, traversing the Atlantic, North America, and the Pacific, and considerably more than half encircling the globe. From a political point of view, the project is therefore one of vast interest and importance.

The distance from Liverpool to Yokohama, by way of Halifax, Montreal, and the Canadian Pacific line, is in round numbers 11,000 miles. Of this the Canadian Pacific Railway proper includes 2,906 miles, of which 2,679 miles lie between Montreal and Savona's Ferry. Between the last point and Port Moody, on Burrard Inlet, there is a section of 213 miles, built by the Dominion government, and not yet, but soon to be, transferred to the company. Port Moody has hitherto been considered the western end of the line. Owing, however, to the insufficiency of the harbor and the unfavorable nature of the surrounding country, the Pacific terminus has been moved fourteen miles down the inlet, to a point where the water next to the proposed piers is sixty feet deep, and where the adjacent lands afford an excellent site for a city. The government of British Columbia has given the company a tract of nine square miles at that place, and a town has already been laid out and named Vancouver.

Besides the main line the company owns 400 miles of road in Quebec and Ontario, the most considerable parts being the North Shore road, 159 miles from St. Martin's Junction, near Montreal, to Quebec, and the Algoma Branch, from Sudbury, west of Lake Nipissing, to Algoma, 96 miles long, but not yet in operation. It also owns and operates 393 miles in Manitoba, of which 64 miles is in a branch from Winnipeg to Emerson, on the international boundary, 182 miles in the Pembina Mountain branch, running south and west from Winnipeg as far as Boissevain, not far from the Dakota line, and 91 miles in the Manitoba and Southwestern, which lies between the last named and the main line west from Winnipeg. On the Pacific end, nine miles is under construction from Port Moody to New Westminster. In addition to this mileage, the Canadian Pacific operates not less than 629 miles in Ontario, in direct competition with the Grand Trunk system.

Of this track, 327 miles lies between Smith's Falls, south of Ottawa, and St. Thomas, on the Michigan Central, and 120 between Toronto and Owen Sound, on Georgian Bay. From the latter point to Port Arthur, where the transcontinental line leaves Lake Superior, the company runs steamers during the season of navigation. The mileage of all the Canadian Pacific rail lines is tabulated as follows:

Main line	2,906
Eastern division branches	401
Western " "	393
Pacific " "	9
Ontario & Quebec leased	576
St. Lawrence & Ottawa leased	53
Total mileage	4,338

That part of the enterprise which has met with the greatest opposition has been the acquisition of the roads above referred to in the Province of Ontario. It seems hard to the managers and shareholders of the Grand Trunk road, for example, that another company which has been presented outright by the government, that is to say by the taxpayers, with the sum of $70,000,000, not to mention a land grant of 18,000,000 acres, should devote no small part of its energies to cutting into their business. It is to be observed, however, that an explicit agreement to maintain rates has been entered into by the two companies; and, though the Grand Trunk loses, and as it believes unjustly, not a little local traffic in Ontario, it must in the course of time secure more or less new business on account of the opening of the transcontinental route, and benefit by whatever benefits the community at large.

For the present, nevertheless, the Canadian Pacific Company is pushing its competitive opportunities to the utmost. Contracts are about to be awarded for the construction of 121 miles of track from Lachine to Smith's Falls. This will make almost an air line, shortening the distance between Montreal and Smith's Falls, as compared with the present route by way of Ottawa, not less than 35 miles, and making the rail distance from Montreal to Toronto about 345 miles, as against 333 by the Grand Trunk. The Smith's Falls route is to be finished this year. The Ottawa business will likely be continued over the present route, but the new line will take the Toronto and Western traffic. An extension of the Ontario and Quebec division from London or St. Thomas to Detroit has been talked of, but will not be carried out at present. The Michigan Central now affords all necessary facilities for connection with Detroit, Chicago, and the Southwest.

A great volume of traffic with the Northwestern States of the Union is, moreover, anticipated on the completion of the lines now under construction from Minneapolis and St. Paul on the south, and Duluth on the north, to Sault Sainte Marie. These, without much question, will be completed by the end of next year. Minnesota capitalists will contribute liberally for the opening of this short route to the Atlantic, while the funds for beginning construction have been obtained through the aid of Canadian Pacific influences. The Minneapolis, Sault Sainte Marie, and Atlantic Railway, in connection with the Canadian Pacific, will place Minneapolis practically as near the seaboard as Chicago. A great amount of business by the northwestern route between the New England States, and possibly New York, and the Northwest is confidently expected. To secure it, the Algoma branch of the Canadian Pacific will of course have to be ex-

tended to Sault Sainte Marie. Plans have been formed for the extension of the present branches in Manitoba and the beginning of new ones, but work thereon will await the convenience of the company.

Turning now to the east end of the system, what are the prospects for better connections with the seaboard? In the first place, a bridge 3,600 feet long is in course of construction across the St. Lawrence at Lachine, eight miles above Montreal. The contract calls for its completion this year, but as the progress of the work depends in some measure on the condition of the river and other uncertain elements, it may not be finished until another season. Having got across the St. Lawrence, the company will push on eastward to Sherbrooke. This may be done either by the construction of a new road or by the absorption of that part of the Central Vermont line which lies between St. Johns and Sherbrooke. In all probability the latter alternative will be adopted. In that event, or even in the former, a road some twenty miles in length will be built from Lachine to St. John.

At this point the Canadian Pacific will secure a direct connection with the Central Vermont line for Boston, while at Farnham, fourteen miles east of St. Johns, it will reach the Southwestern road, which forms a link in the Montreal and Boston Air Line, now composed of the Boston and Lowell, Passumpsic, and Southwestern roads. The Canadian Pacific owns a large interest in the Southwestern property, and will no doubt utilize it as far as possible for a Boston connection. The line from Lachine to Farnham will be brought into operation upon the completion of the bridge. The relations between the Boston and Lowell and Canadian Pacific companies are cordial. Within a few months, therefore, the latter will practically have an independent line of its own from Boston to Vancouver. For some time to come, Boston will thus virtually be the Atlantic terminus of the Pacific line. Portland may, perhaps, receive some share of the traffic by way of the Portland and Ogdensburg road.

speedy collapse, that there is much reason to anticipate the ultimate carrying out of this vast project. Skeptics are much less numerous than they were five years ago.

But the scheme does not end here. Negotiations are in progress for the establishment of a first-class line of steamships between Vancouver and Japan and China. It is thought in Montreal that the British government will without doubt grant a sufficient subsidy for the mail service by this route to pay the running expenses of the vessels, even though they were to get no freight or passengers. Connections with Australia are also under consideration. Apart from this project, a service between Vancouver and San Francisco has been arranged for. On the Atlantic, a line between Halifax and Liverpool, with vessels capable of making the run in six days or less, is under advisement. Halifax being one day nearer Liverpool than New York, there will be no difficulty in getting steamers of the requisite speed. This line having been established, two mail trains, or more if necessary, each month will be run in connection with the steamers from Montreal to Vancouver in ninety hours. The ordinary passenger trains will make the trip in about 120 hours. In at least one instance, merchandise has already been carried from Glasgow to Port Moody in fourteen days. The time from Port Moody or Vancouver to Yokohama is placed at twelve days.

Upon the establishment of the steamship service just outlined, a transfer of all the English mails to and from China and Japan to the Canadian Pacific route is looked for as a matter of course. So far as Australian and Indian mails, passengers, and freight cross the American continent at all, they will likewise, it is thought, follow the Canadian line.

Comparative statements made up by the company show that the distance from Liverpool to Montreal is 3,040 miles, and from Liverpool to New York 3,431, from Liverpool to Vancouver 5,946 miles, and from Liverpool to San Francisco 6,700; from Liverpool to Yokohama *via* the Canadian Pacific 10,974 miles, and from Liverpool to Yokohama *via* Sa Francisco, 11,990. From New York, moreover, to Vancouver, *via* Brockville, it is 3,162 miles, or *via* Montreal 3,297 miles; from New York to Portland, Or., by the Northern Pacific 3,235 miles, and from New York to San Francisco 3,269 miles. The distance from San Francisco to Yokohama being 5,290 miles, and from Vancouver only 5,028, New York is 8,559 miles from the Japan port by way of San Francisco, and 8,190, or 369 less, by way of Vancouver. The Canadian Pacific managers accordingly look for something of an interchange of business by their route between New York and Asia, though they base no extensive calculations on this traffic, or indeed on traffic between any of the eastern cities of the United States and the Pacific coast.

So far as the extension of the system eastward to the Maritime Provinces is concerned, the parties in interest are very close mouthed. There is a sharp rivalry between Montreal and Quebec for the honor and profit of becoming the starting point for the route to the seaboard, while on the coast St. John and Halifax are no less persistent in advancing their rival claims. The Canadian government, however, has subsidized the International line, which has been chartered to traverse the State of Maine from west to east, starting from Lake Megantic, which is already connected with Sherbrooke, and striking the Maine Central system at Mattawamkeag within 56 miles of the New Brunswick boundary. In Canadian Pacific circles no lack of confidence is professed in the ultimate construction of this short route to the Provinces. As now laid out, it will cross Moosehead Lake and run south of Mr. Katadin. It is also proposed to build from some point on the New Brunswick road east of its junction with the Maine Central, by way of Fredericton to Moncton, N. B., from which place the Intercolonial line affords direct connection with Halifax. It is a matter of interest, moreover, that a road already runs still further east from Truro, N. S., to the Strait of Canso, and that within a few days the Dominion Minister of Railways has given notice in the House of Commons of a government scheme for the construction of a line across Cape Breton island from the strait to Louisburg or Sydney. The route as just laid out is almost an air line from Montreal to the furthest confines of the British possessions in America, except of course the island of Newfoundland.

The distance from Halifax to Montreal, by way of the Intercolonial road, is 839 miles, and the running time for passenger trains is about thirty-five hours. By way of the short line across Maine, the distance will be about 500 miles, and the time required will not exceed sixteen or seventeen hours. It may be a matter of several years before the "short line" is completed, but the Pacific enterprise has already reached such proportions, in the face of frequent predictions of its

SCREW PROPELLER RAILWAY.

By J. R. Gorman.

Having had occasion to travel toward Ootacamund, the inventor was very much struck by the abrupt termination of the railway at Metapollium, and this made him inquire into the cause, when the answer was apparent in the deep valley and steep hills before him. Upon this he set himself the task of hitting upon some contrivance to overcome this difficulty, resolving to treat the whole question as a problem.

Accordingly, he first asked himself what a ghat was, and (in mechanical language) the answer was "an inclined plane." This led to the conception of an inclined spiral path round a conical hill, which is simply a taper screw. The idea then occurred to him to overcome the difficulty of a screw by a like mechanical advantage—in short, to throw the ghat on a screw propeller. Upon this principle, he began to work, and the result is set forth in the annexed specification and drawing.

The invention consists of an immense screw with a widely pitched thread working in a central rail, cut so as to accommodate itself to the screw and form its counterpart or companion.

The screw will be fitted in two bushes, which are rigidly fixed to the frame of the propeller, as shown in plan, Fig. 4. This frame itself will be mounted on wheels so as to run on the ordinary rails like an ordinary van.

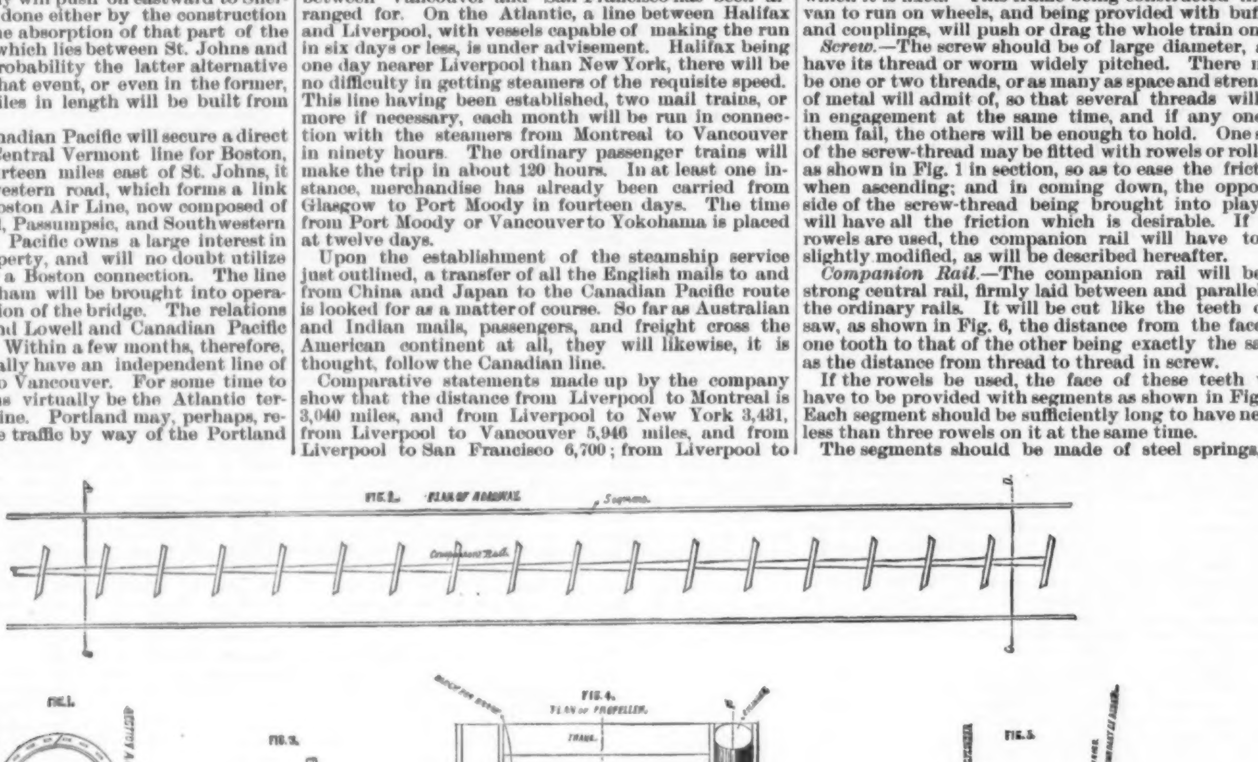
The center shaft of the screw will have two cranks, one at each end, which will be worked by the piston from the cylinder. When the piston moves the crank, it will cause the screw to revolve, and the screw, being in engagement with the (central) companion rail, will be propelled onward, forcing with it the frame in which it is fixed. This frame being constructed like a van to run on wheels, and being provided with buffers and couplings, will push or drag the whole train on.

Screw.—The screw should be of large diameter, and have its thread or worm widely pitched. There may be one or two threads, or as many as space and strength of metal will admit of, so that several threads will be in engagement at the same time, and if any one of them fail, the others will be enough to hold. One side of the screw-thread may be fitted with rowels or rollers, as shown in Fig. 1 in section, so as to ease the friction when ascending; and in coming down, the opposite side of the screw-thread being brought into play, it will have all the friction which is desirable. If the rowels are used, the companion rail will have to be slightly modified, as will be described hereafter.

Companion Rail.—The companion rail will be a strong central rail, firmly laid between and parallel to the ordinary rails. It will be cut like the teeth of a saw, as shown in Fig. 6, the distance from the face of one tooth to that of the other being exactly the same as the distance from thread to thread in screw.

If the rowels be used, the face of these teeth will have to be provided with segments as shown in Fig. 3. Each segment should be sufficiently long to have never less than three rowels on it at the same time.

The segments should be made of steel springs, so



PLAN OF A SCREW PROPELLER AND ROADWAY INTENDED FOR VERY STEEP GRADIENTS.

that they may be elastic and accommodate themselves to any deviation due to curves or bends.

The invention being only a propeller, it need only be attached behind the engine, when the present ordinary arrangements of switches and crossings may be used. The leading wheels of the engine will take the points, while the propeller, as an auxiliary, simply pushes the engine on, or pays it out in ascending or descending.

At the crossings, it may be found that a segment comes exactly at the intersection of two rails. In a case of that sort, the position of the segment should be shifted so as not to interfere with the wheel. If that cannot be done, that particular segment should be left out. The screw being sufficiently long to bear upon 6 or 8 at the same time, the absence of one or even two segments will not be felt. In the plan the screw is shown as moved direct by the piston; we are not tied to this arrangement; the screw may be made smaller, multiplying wheels may be introduced so as to increase the speed, and for the brake, too, multiplying wheels may be introduced and the brake-block brought to bear on the fly-wheel.

If this is to be done, the cog-wheels may be arranged in the place marked in plan, Fig. 4.

Two buffer-springs will be introduced between the screw and the bushes to avoid jerking, and also to give the screw more playing room.

Variations.—The diameter of the screw and the pitch of the thread may be varied as desirable. It is evident that the larger the diameter, the greater will be the speed. In the same way the wider the pitch, the greater will be the speed; but, on the other hand, these will be limited by the strength of the material, as the strain on the parts will be increased.

The principle throughout is the same. It is simply a large screw working in a central rail forming the counterpart of the screw, and the proportions may be adjusted as desirable in each case.

Advantages.—The great difficulty we have to contend with is not that we cannot get together enough of force to pull us up, but that the rails do not afford

sufficient frictional resistance to prevent the weight of the train pulling the engine back by its gravity. The very formation of the screw does away with this difficulty, and we have quite as much friction as is desirable (if not more) in going up and ample friction in coming down. If the friction be found too great in ascending, the rowels may be used as suggested above. Another advantage is that, with a screw propeller, the engine and tender need not be near so heavy as they are at present, and, consequently, the permanent way and bridges need not be so massive. The cost of this extra central rail will be great, it is true, as also the wear and tear, but, on the other hand, it must be remembered that about 75 per cent. of initial cost of making a permanent way, and the maintenance and other incidental expenses of this 75 per cent., are all saved, to say nothing of this system requiring a much lighter set of bridges and rails, as it is not dependent on the weight of its engines for its tractive power, but on the screw. At present, the engine and tender weigh about one-third the whole weight of a full train; but if this plan be adopted, the engines need not be heavier than is absolutely required for due strength.

The saving of 75 per cent. of road is effected in ghats by the gradient being four times as steep as the steepest railway ghat used in India, this being 1 in 10; while the steepest railway ghat in India is about 1 in 40.

CALCULATION.

Let the diameter of cylinder of screw = 6 feet, pitch of screw = 1 diameter in each revolution, or

$$\frac{\text{Circumference}}{\text{Rise}} = \pi \text{ or } \frac{22}{7};$$

Let gradient = 1 in 10;
Cylinder = 24 inches diameter;
Piston = 24 inches stroke.

We know from experiment that we require from 8 to 10 lb. of pressure for every ton weight on a level road.

$\therefore$ If w represents weight of train,

$$\frac{10}{2240} w = \frac{1}{224} w =$$

resistance due to friction on rails; also $\frac{1}{10} w$ = resistance due to gradient 1 in 10.

Adding these we get

$\frac{1}{224} + \frac{1}{10} w$ = force required along axis of screw to balance w.

Now, $\frac{7}{22}\left\{\frac{1}{224} + \frac{1}{10}\right\} w$ = *this* force resolved to the circumference.

To this must be added friction, which is 0·1 for metal on metal at rest, and 0·07 in motion. Let us take the greater resistance, which is

$$\frac{1}{10}\left\{\frac{1}{224} + \frac{1}{10}\right\} w;$$

$\therefore \frac{7}{22}\left\{\frac{1}{224} + \frac{1}{10}\right\} w + \frac{1}{10}\left\{\frac{1}{224} + \frac{1}{10}\right\} w$ = total force at circumference.

Now the leverage of crank is to leverage of shaft of screw as 1 : 3;

$$\therefore 3\left\{\frac{7}{22}\left(\frac{1}{224} + \frac{1}{10}\right) w + \frac{1}{10}\left(\frac{1}{224} + \frac{1}{10}\right) w\right\}$$

$$= 3\left\{\frac{7}{22} + \frac{1}{10}\right\} \left\{\frac{1}{224} + \frac{1}{10}\right\} w$$

$$= 3\left\{\frac{35 + 11}{110}\right\} \left\{\frac{5 + 112}{1120}\right\} w$$

$$= 3\left\{\frac{46}{110} \times \frac{117}{1120}\right\} w$$

$= \frac{8073}{61600} w = 0·131\, w$ = force at piston head when w is just on the point of motion.

But $\frac{12 \times 12 \times 22 \times 2 \times 120}{7}$ = 108,617 lb. = pressure on two pistons with steam at 120 lb.

The following table will show approximately the variations for a stroke varying from 24 to 6 inches with a cylinder varying from 24 to 30 inches:

Length of stroke.	Speed per hour.	Weight that can be lifted up a slope of 1 in 10 with two cylinders varying in diameter as below.						
		24″	25″	26″	27″	28″	29″	30″
	Miles.							
24	6	370	401	434	468	503	540	578
23	6	354	384	415	448	482	517	553
22	6	339	367	397	429	461	495	529
21	6	323	350	379	409	440	472	505
20	7	308	334	361	390	419	450	481
19	7	292	317	343	370	398	427	457
18	8	277	300	325	351	377	405	433
17	8	262	284	307	331	356	382	409
16	9	246	267	289	312	335	360	385
15	9	231	250	271	292	314	337	361
14	10	215	233	253	273	293	315	337
13	11	200	217	235	253	272	292	313
12	12	185	200	217	234	251	270	289
11	13	169	183	198	214	230	247	264
10	14	154	167	180	195	209	225	240
9	16	138	150	162	175	188	202	216
8	18	123	133	144	156	167	180	192
7	20	107	116	126	136	146	157	168
6	24	92	100	108	117	125	135	144

Making an equation of these, we have:

$$0·131\, w = 108{,}617, \text{ or } w = 829{,}137 \text{ lb.} = 370 \text{ tons.}$$

For speed:

It has been ascertained that, to get the full benefit of steam, a piston head may be made to move 360 ft. a minute.

So, a cylinder with a 24 inch stroke will make

$\frac{360}{2}$ = 180 single or 90 double strokes in a minute.

We know from the construction that the propeller will advance 6 feet per revolution or double stroke of piston, *i. e.*, 540 feet per minute will be its speed, *i. e.*, 32,400 feet or 10,800 yards = 6 miles per hour.

This speed may be increased by reducing the length of stroke, in which case the power will be reduced proportionately. But we may make up for this by increasing the diameter of the cylinder.—*Indian Engineer.*

EXCAVATION AND EMBANKMENT BY WATER POWER.

By EDWARD BATES DORSEY, M. Am. Soc. C.E.

I WISH to call the attention of the Society to a plan by which large excavations and embankments can be cheaply made—which is especially applicable to earthen dams—by simply applying the method used in the hydraulic mines that have been so largely developed in California. The system, in brief, is discharging the water under a vertical head of from 100 to 300 feet against the bank to be excavated. The momentum of the water cuts the bank, the material of which is conveyed by it into the flume, and thence by it to the place at which it is to be discharged.

This point of discharge is generally in some watercourse or river, which soon becomes dammed by a perfectly water-tight dam, which remains intact and tight until it is destroyed, or partially so, by the winter's flood washing away the material from the top.

The water used in the mines is generally brought from reservoirs in the mountains. The dams forming these are brilliant examples of bold and cheap construction; among the principal of these is the Bowman Dam, on the headwaters of the Yuba River, in Nevada County, California, built under the general direction of Mr. Hamilton Smith, Jr., M. Am. Soc. C. E. Its maximum height is 100 feet, and length 425 feet.

The water from the reservoirs is conveyed through ditches, tunnels, flumes, and pipes to the mines; in some cases aggregating a length of several hundred miles. These flumes show at times very bold engineering, being hung by iron rods to the vertical sides of the mountains; at other times they cross wide and deep valleys upon high and long trestle-work. When the valleys are too deep to be crossed in this manner, inverted siphons are used, made of wrought-iron sheets riveted into pipes. The great pressure these pipes stand, their lightness, durability, and cheapness, will, in the future, force their adoption in many cases upon the hydraulic engineer. Some of these works, generally known as mining ditches, eclipse in magnitude and boldness the waterworks supplying most of our or European large cities.

The unit of measurement of water in California is what is known as the miner's inch, which varies in different localities; the inch that is generally adopted equals 17,000 United States gallons in twenty-four hours.

The quantity of earth that this miner's inch will remove varies very much, being from 1½ to 9 cubic yards daily. Perhaps the most correct date is from the workings of the North Bloomfield Gravel Company, under the direction of Mr. Hamilton Smith, Jr.

During 1874–75, one inch of water removed 4·80 cubic yards gravel.

During 1875–76, one inch of water removed 4·17 cubic yards gravel.

In many cases the engineer in constructing dams could do better than this, as he could pick out the soft places and leave the hard, and not waste time and water in cleaning the bed rock or working the hard blue gravel, which is generally richest in gold, and in mining operations must necessarily be mined and removed, even if it is done slowly.

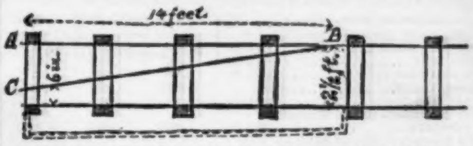
In order to be perfectly safe, I have estimated that the miner's inch of 17,000 United States gallons daily will remove 3½ cubic yards. Upon this basis, actual bids were received for the construction of the plant, embracing engines, boilers, etc., to pump 20,000,000 gallons 200 feet high in twenty-four hours.

Recently I had to estimate the cost of constructing a dam 80 feet high. The surroundings prevented the use of masonry; the nearest material that would answer for puddle would have to be hauled four miles up a very steep grade; the only material available for building the body of the dam was a sandy gravel extending to the greatest explored depth. By the numerous tests the voids ranged from 8 to 23 per cent., averaging 10 per cent.

As the building material, as well as the foundation, was bad, I deemed it prudent to give the dam extra width; consequently the top was estimated 200 feet wide, with slope 2½ to 1 on each side, making the bottom 600 feet. One of the reasons for giving this great width was to get plenty of fine material for the interior filling that would take the place of the ordinary puddle. The calculated quantity of material was 1,757,127 cubic yards.

The plan proposed was to pump the water to an average height of 200 feet; of this, 120 feet would be available for hydraulic purposes, the remaining 80 feet would be lost in friction, fall of the flume, and dump. It was proposed to convey the water from the pumps to the banks by the usual hydraulic mining pipe, made by riveting together sheets of wrought iron. The water and the material would be conveyed to the proposed dam embankment in a flume 2·5x2·5 feet, made out of 1½ inch planks, with a fall varying from 5 per cent. at the beginning of the work to 2 at the close. This flume would be made similar to the ordinary mining flume, except that it would not be paved in the usual manner, either with stone or wooden blocks, but the bottom would be lined with thin sheets of steel plates, to prevent the wearing of the planks and to make the friction of the water and the conveyed material as small as possible. A few feet from the discharging end of the flume the upper portion of the side of the flume toward the center of the embankment would be cut away, commencing say at a point 14 feet back, where the height of the side would be 2½ feet, and diminishing to say 6 inches at the end, thus:

SIDE ELEVATION OF FLUME.



A B represents the outside of flume, 2½ feet high.

B C represents the side toward the center of the dam as cut away.

The dotted lines represent a trough or box to catch the overflow from B C.

By this plan, most of the water containing the lighter and finer materials only would overflow into the trough represented by the dotted lines as above, and be conveyed by smaller branch flumes toward the center of the embankment, where it would be discharged and settle, forming a center of fine puddle; the stones, gravel, and coarse sand would be on or near the bottom, below the side opening, consequently they would be discharged at the end, forming an excellent riprap for the embankment. This side opening could be raised or lowered as the material or work might require.

I will briefly describe the plan that I proposed to adopt in building this dam, using for example a dam 80 feet high and 200 feet wide on top, with slopes of 2½ horizontal to 1 vertical.

Fig. 1 represents the ground prepared for construction.

FIG. 1.

A, the usual puddle ditch, the material from which would be used to make B and C, small embankments, ten to fifteen feet high, at the extreme base of the main embankment, this being to retain the muddy water until the finer particles held in suspension are deposited, so as to waste as little material as possible.

Fig. 2 represents the first hydraulic working, the flumes, F F, being 20 feet above the bottom—one on each side of the embankment. So that there may be no loss of time, while one is working the other can be moved or altered as desired, care being taken in this, as in all subsequent operations, to keep the outside or rip-rap portion of the wall closely built up to the discharging end of the flume. By doing this, a few planks, brush, and stones can easily control and divert the water wherever desired.

FIG. 2.

The outer wall in this, as well as in all subsequent stages, should be kept as high as possible, in order to save the muddy water until the sediment in suspension is deposited.

Fig. 3 represents the second hydraulic stage. In this the flumes, F F, are 40 feet above the bottom.

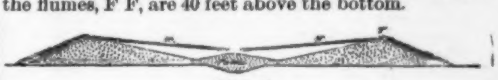


FIG. 3.

The upper part of the water in the flume, containing the finer material, escapes over the low side opening into the trough and branch flumes, H H, and is discharged over the puddle pit.

In this case it was estimated that one-fourth of the total quantity would be deposited here, and would make a most excellent puddling material. However, this proportion could be easily varied by raising or lowering the side discharge, as may be found desirable, to make the puddle finer or coarser.

On the figures the puddling material is represented by the broken horizontal lines, which also indicate approximately the form it would assume from the deposits made during the different stages.

Fig. 4 represents the third hydraulic stage, the flume being 60 feet above the bottom of the embankment.

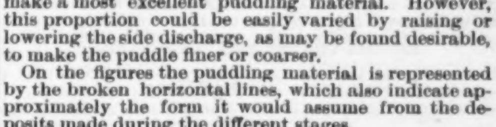


FIG. 4.

Fig 5 represents the fourth or last hydraulic stage.

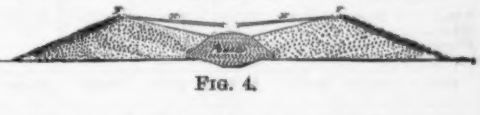


FIG. 5.

In this case there was not enough water running in the stream to give an average of 20,000,000 gallons daily. It was proposed to keep the water between the two embankments as long as possible, then to allow it to escape into the reservoir being formed by the dam, where it would deposit on the sides and bottom (which might be very desirable in some formations) the remaining sediment in suspension. After this it could be pumped again against the bank. By thus using the same water over repeatedly, very little fresh water would be required.

COST.

The following table is taken from the able paper on "Hydraulic Mining in California," by Aug. J. Bowie, M. Am. Soc. C. E.*

* Hydraulic Mining in California. By Aug. J. Bowie. Transactions of the American Institute of Mining Engineers, vol. vi., page 27.

Name of Mine.	Year.	Cost Per Cubic Yard Moved.		
		Water.	Total.	Total except Water.
French Hill Claim	1874-76	$0.014	$0.063	$0.049
Light Claim	1875-76	.006	.038	.032
Chesnan Claim	1874-76	.008	.055	.047
Johnson Claim	1875	.006	.067	.061
Sicard Claim	1874-75	.004	.039	.035
North Bloomfield Gravel Mining Company	1874-75	.0077	.0207	.0130
North Bloomfield Gravel Mining Company	1875-76	.0074	.0245	.0171

The two last were made under the superintendence of Mr. Hamilton Smith, Jr., M. Am. Soc. C. E., in his usual thorough manner, and give the correct cost, under favorable circumstances of high banks, plenty of water, good grade, and first-class management.

The engineer in any ordinary work could not expect to equal this work of Mr. Smith; but he would, in my judgment, except under very unfavorable circumstances, be perfectly safe in estimating at four cents per cubic yard the cost of digging, transporting, depositing the material in embankment, and all other expenses, except that of water and plant.

The preceding statement of expenses at the mines included many items of expense not necessary in ordinary engineering work, such as loss of quicksilver, loss of labor and water in cleaning bed rock; watchmen to prevent robbery of gold; expenses of saving the gold; expenses of cleaning up, etc.

COST OF PLANT.

A plant capable of pumping 20,000,000 gallons of water 200 feet high daily, which should remove 4,117 cubic yards of average earth or gravel, will cost, all complete and in working order, about $50,000, unless the local freight should be excessive. This is made from actual bids.

In this latitude this system could be worked all the year except during the severe winter months, say for 200 days, in which time it would remove 4,117 × 200 = 823,400 cubic yards, so that the cost of the plant would be as follows per cubic yard removed. In work lasting:

One year	$0.06
Two years	0.03
Three years	0.02
Four years	0.015

In this estimate nothing is allowed for the value of the plant at the end of the work. The engine, boilers, pumps, tools, electric lights, etc., would certainly bring something, which would reduce it materially.

In warmer climates, where the work could be prosecuted all the year, the above estimate would be largely reduced.

COST OF WATER.

Wherever this system could be used in ordinary engineering work, the time that would be required would generally be too short to justify the purchase of compound or condensing engines, consequently the cost of pumping is calculated on the ordinary high-pressure engine consuming 36 tons of coal to pump 20,000,000 gallons daily 200 feet high:

36 tons of coal, at $4.50	$162.00
1 engineer	4.00
2 assistant engineers	6.00
2 firemen	4.00
4 laborers	6.00
Oil, waste, etc	8.00
Total	$190.00

$190 ÷ 4,117 = $0.046. Average cost per cubic yard, say $0.045.

This estimate is based upon the supposition of pumping all the water 200 feet high, but in most localities a few cheap dams and ditches could be made to bring considerable water at an elevation that would materially reduce this pumping expense.

RESUME OF COST PER CUBIC YARD.

	Duration of Work.					
	1 Year.	2 Years.	3 Years.	4 Years.	5 Years.	6 Years.
Water	$0.045	$0.045	$0.045	$0.045	$0.045	$0.045
Plant	.06	.03	.02	.015	.012	.01
All other expenses	.04	.04	.04	.04	.04	.04
Total	$0.145	$0.115	$0.105	$0.100	$0.097	$0.095

In my opinion this plan will often enable the engineer to build cheap and safe dams where it would be impossible to build, at any reasonable cost, masonry or earth dams.

It could be used for excavating and removing all classes of earth or soil, except compact pipe clay. For constructing or building up embankments, it cannot be advantageously used where the earth for constructing the proposed work contains a great quantity of loam or clay; for this purpose the earth should contain a fair percentage of gravel and sand.

The cheapness with which the material can be moved by this system enables the engineer to use a much greater quantity than he would think of doing with the usual expensive systems.

Based upon my experience, I think a safe dam can be made of sand or on a sandy foundation, provided sufficient thickness is given to it, so that the head of the water will be neutralized by its friction in passing through the sand. This dam will undoubtedly leak, but probably not as much as required for compensation to the riparian owners on the stream below. This leakage will diminish with time, owing to the deposit of sediment on the bottom and sides of the reservoir. This deposit could be accelerated to any desired extent in the proposed plan by running the muddy water from the flume into the reservoir.

Wherever this plan can be adopted, it should commend itself to the engineer for several reasons:

First.—It will be much cheaper than the earth dam constructed in the usual manner—at least one-half, where the material is good; and where the material is bad, the difference would be still greater, probably one-fourth.

Second.—It will permit the construction of earth dams where the material is so bad that the ordinary dam could not be constructed.

Third.—Owing to the cheapness, the dam could be made much stronger.

Fourth.—The dam will not settle or crack. It is as compact and as solid at the beginning as it can be made.

Fifth.—As it will not settle or crack, it is ready for use as soon as it is finished.

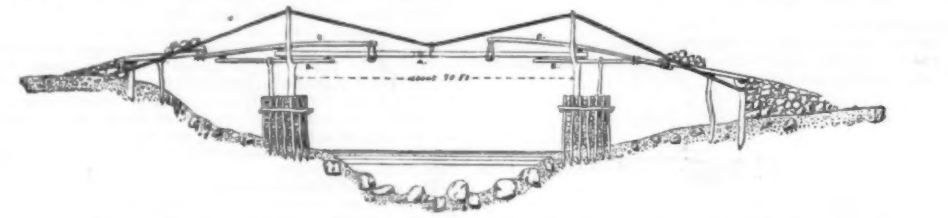
In the proposed plan, there is nothing new, except that the working head of 120 feet is derived from pumping machinery instead of gravity. This makes no difference in the result, except in increasing the cost. The prices of plant named in this paper are actual bids from manufacturers, with a guarantee not to burn more coal than estimated. In every other respect the plan is identical with that which has moved millions of tons in California, at a cost impossible by any other method.—*Trans. Amer. Soc. Civil Engineers.*

MEXICAN BRIDGE CONSTRUCTION.

By J. FOSTER FLAGG, M. Am. Soc. C.E.

THE accompanying sketch is submitted as being rather remarkable for the work, from his own design, of an ordinary uneducated Mexican laborer, or *peon*—combining as it does, crudely, several principles of bridge construction.

Bridges in Mexico are, generally speaking, built of arched masonry, anything like a truss, especially in the section of country where this bridge was built (the State of Colima), being before the advent of railroads almost unknown. In the State of Colima there are but few bridges of any description—the streams being crossed, when possible, by the primitive method of fording—and these few are the usual arched structures. The River Armeria, crossed by the bridge sketched, is, for a long distance above and below the bridge site, too rapid (having an average slope for miles of one per cent.), and generally, even in the lowest stage of water, too deep to be fordable. And the size of the river in flood (then 800 feet wide and 25 feet deep in the channel), and the instability of its stony bed, make it altogether too expensive a matter with the limited means of the country to build a permanent high bridge. It was attempted some thirty-six years ago, thirty miles farther down, where the current is much less rapid—



SKETCH OF A MEXICAN BRIDGE BUILT BY A COMMON PEON

a structure of the usual character (a series of brick arches of limited span), of probably 800 to 1,000 feet in length, being then built; but a freshet, the following year, cleaned out the whole structure, except an arch or two at one end.

The *peon* referred to was occupied some four years ago as a ferryman where the trail for cargo mules crosses the river, carrying across the mule packs, pack saddles, etc., in a "dugout." And if any animals could not be forced to swim the rapid current by pelting them from the banks, he stripped himself, and, seizing the bell mare or riding animal by the mane, swam beside her, and forced her across to lead the rest. About that time he happened to see a *Harper's Weekly* (probably sent to some one of our engineers) which had in it an illustration of a suspension bridge. This was a new light to him, and he revolved the matter over in his mind to see if he could not imitate the bridge in the materials at his command, viz., the round sticks and vines cut from the forest, and small, rough-hewn sticks of timber.

As a result he put up a structure closely imitating the ordinary suspension bridge, the cables and suspenders being twisted from wild vines (*bejucos*), and the former passed over rude frames for towers, and anchored to huge bowlders in the river banks. It was built without any nails or iron of any kind. It was, of course, a frail structure, but it served very well for foot passengers, and for carrying across on wheelbarrows, or the backs of *peons*, the cargo of the mules. The writer found it quite an assistance in passing backward and forward men and tools employed in building a railroad bridge at the same site.

But a heavy freshet occurred the same year the bridge was built, and destroyed every vestige of it. Finding it profitable, the *peon* engineer decided to renew it; and this time he was not satisfied with copying another's design, but originated the one submitted with this paper.

Like the first one, it was put together without nails or metal of any description—the suspension cable, as before, being made of wild vines twisted, and all joints tied together with lighter vines used when green, no manufactured ropes even being used.

The piers were made by driving light poles a short distance into the river bed, in the form of a square, tying them together with other poles, and filling with stone. The stringers of the main span, in two pieces, were tied together with *bejucos* at A, and the spliced stick supported near the joint by the suspension cable—the only use to which the cable was put. The towers were natural forked sticks; forked to support the cable, and forked to support the corbels, B B, which assisted in shortening the main and lateral spans.

And finally the long stringers were supported again, midway between the end of the corbels and the cable attachment in the center, by crude cantilevers, C C, which were loaded with stone near their shore ends to balance the weight of the central span.

The roadway, of rude joists and boards, is not shown. It was quite narrow, only one animal being able to pass on it at a time. The bridge proved to be strong and rigid enough to pass mounted men or loaded mules, and so served better than his first construction. It was in use, I believe, without any accident, for some 18 months, when another heavy freshet unfortunately sent it the way of its predecessor.—*Trans. Am. Society Civil Engineers.*

RING THROSTLES.

THE best system of ring throstle, both in principle and the arrangement of its parts, and the one which can now serve as a type, is, in our opinion, that of Mr. J. J. Bourcart, of Zurich (Fig. 1).

There is a general agreement as to the advantages that ring spinning possesses over the self-acting method, and these are as follows: (1.) In it the motions are continuous, and offer no danger to the workman. (2.) It requires but half the space, heat, light, and shafting. (3.) It produces from 30 to 50 per cent. more than the self acting method does. (4.) It permits of a saving in manual labor varying from ¼ to ⅞. (5.) The bobbins are taken off in two or three minutes by a well-arranged set of operations, and this time no longer counts as lost.

We shall first enter into some theoretical considerations that will clearly show all the difficulties that have had to be surmounted in order to reach the present degree of perfection found in ring mules, taking as a starting point the ring and traveler throstle invented by Thomson in 1809.

In order to understand this machine, it is necessary to analyze what occurs in an action that requires (1) the thread to be fed over a guide (Fig. 2); (2) the thread to be passed through a traveler consisting of a C-shaped piece of steel, that slides freely upon a fine and well-tempered steel ring, having in its upper plane a thin flange; and (3) the thread to be wound upon a continuously moving spindle by a vertical motion of the ring-holder carriage or of the spindle. Fig. 2 shows the principle of every ring throstle.

That portion of the thread which is in course of formation between the guide and the traveler is called "balloon thread," while the fraction between the traveler and the spindle is known as "tangent thread."

The first of these threads is so called because, when it is carried along by the swiftly revolving spindle, it gives the eye the impression of a pear-shaped object, called a balloon.

The winding of the thread is effected through the friction of the traveler upon the ring, the latter being carried along by the tangent thread. This latter, sliding in the traveler, takes its bearing point upon the balloon thread, and it is only then that it can carry along the traveler sliding upon the ring. From this there result two tensions: (1) that of the balloon thread, and (2) that of the tangent thread. These two tensions combined have to balance the friction of the traveler on the ring—a friction that has two origins, the centrifugal force of the traveler and the tension of the balloon and tangent threads. The amount of such friction can be accurately determined as follows (Figs. 3 and 4):

Let m be the mass of a body moving over a circumference; m is influenced by the tangential force $m\,v$ and the centripetal force $m\frac{v^2}{r}$, directed toward the center. If m be the mass of the traveler, and r that of the thread, we shall have:

$$(m+n)\frac{v^2}{r} = 0{\cdot}000005 + 0{\cdot}0000012 \times 15 \times 15 : 0{\cdot}025 = 0{\cdot}0565\,k.$$

$$(m+n)\,v = 0{\cdot}000094$$

$$600\,m\,v = m\frac{v^2}{r}$$

If the centripetal force ceases, m will move in a straight line, according to a tangent to the circle, and, if an obstacle comes in the way, m will be influenced by the centrifugal force $m\frac{v^2}{2}$, and will follow the circular resultant. If the obstacle be a circle, m will then have a friction upon it equal to $F = m\frac{v^2}{r} \times f$. If $f = \frac{1}{4}$ and $m = 0{\cdot}000005$, it results that $F = 0{\cdot}0064\,k$.

On another hand, if A be the tension of a thread, C, drawn through an eye, t, sliding upon a rod, i, the thread, C, will have a tension nearly equal to A. The resultant of A and C will be D. If the angle a be 90°, D will equal 1·40 A; if a = 60°, D will equal 1·80 A. This resultant, D, produces obliquely upward a friction, f, upon the ring, $f = \frac{1}{4}$ D = 1·40 to 1·80 A × $\frac{1}{4}$. Now the angle a = 90° at the beginning of the bobbin and 60° at the end, in ring throstles with fixed thread-guides, wherein the traveler rubs against the edge of the ring. Further along we shall see why Mr. Bourcart has adopted a movable thread-guide rather than a fixed one.

The friction due to centrifugal force is in direct ratio of the diameter upon which the tangent thread winds, from the moment at which the weight of the traveler is such that its centrifugal force is capable of balancing the strongest tension of the tangent thread. It can prove but advantageous in good spinning.

The friction due to tension will be incalculable if the diameter over which the thread is wound descends beneath a certain minimum, and if the weight of the

traveler be sufficient. It can prove but a drawback in spinning (Fig. 5). Let A be the tension of the thread upon the large diameter of the bobbin, and it will produce upwardly a friction of the traveler equal to $\frac{1}{7}$ A, then a centripetal force 3, and finally a tangential force S. The friction upon the ring produced by the centrifugal force of the traveler $= m \frac{V^2}{r} \times \frac{1}{7} = F$. The upward and external frictions. The first of these is overcome as soon as the tension of the tangent thread is not transmitted to the bottom thread; the second exists only when the machine is set running, if the traveler be heavy enough.

There is one other quite troublesome effect that occurs (Fig. 6), and that is that the spindle, actuated by a card, slides too freely when the card is no longer taut enough. This is what takes place:

bobbin, which is the same as saying that $\frac{d\,w_0}{d\,w_1} = \frac{\beta_1}{\beta_0}$.

Now, in order to obtain a uniform tension upon the wound thread, it is necessary that all the thread paid out shall be absorbed by a proportional velocity of the bobbin, and that there shall be the above equality. On fulfilling one of these conditions, we at the same time satisfy the second.

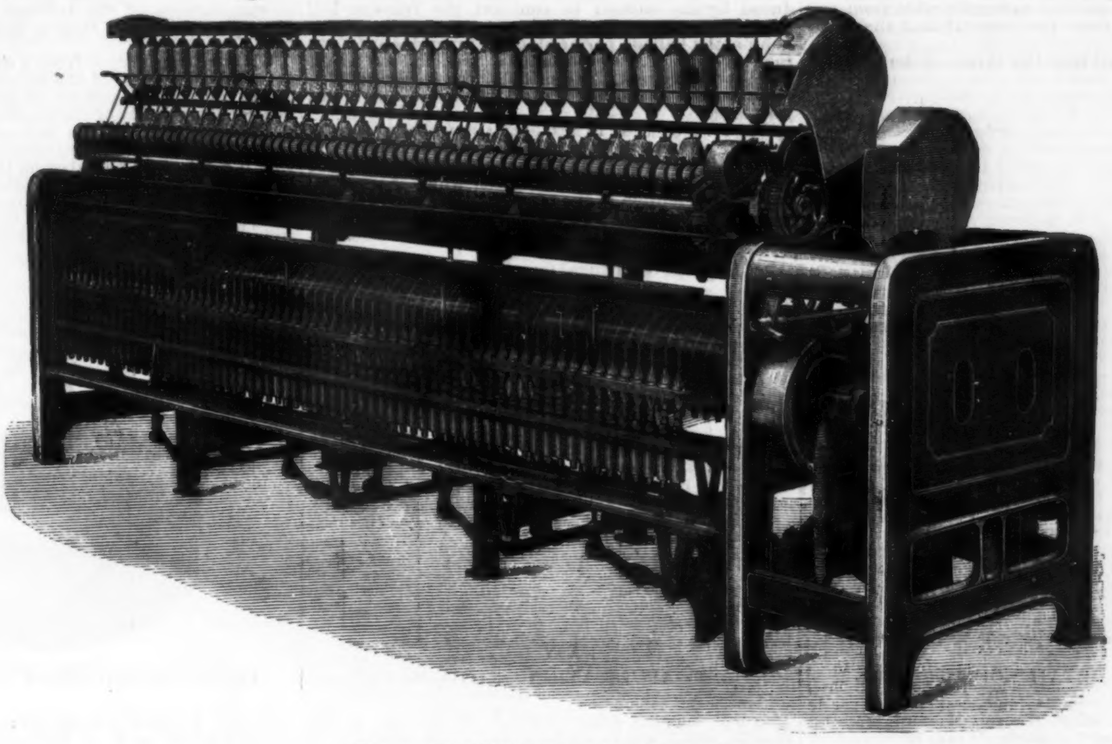
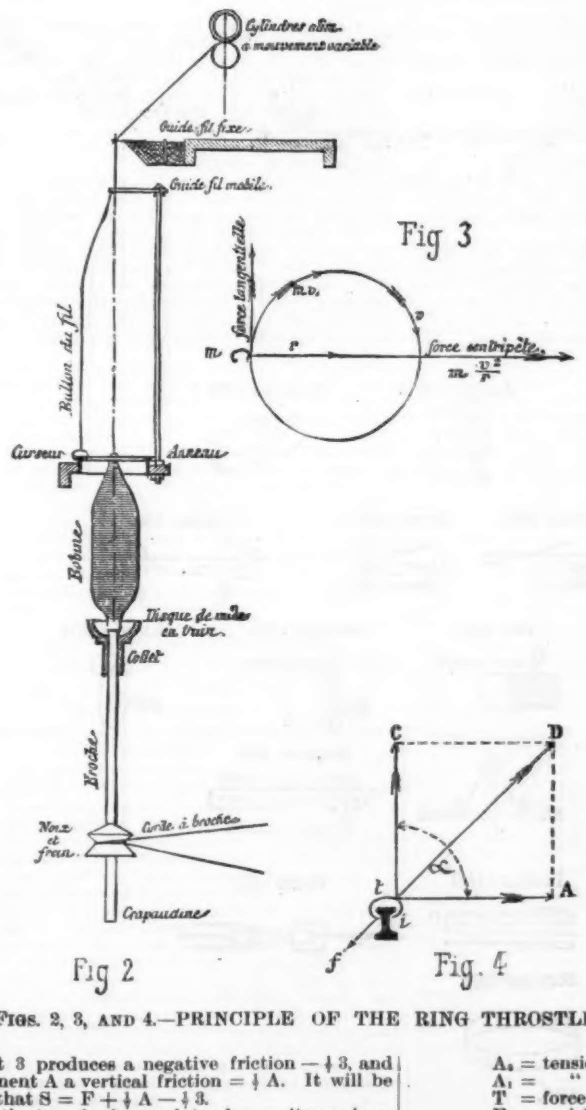


FIG. 1.—BOURCART'S RING THROSTLE.



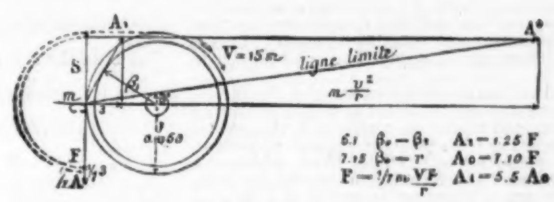


FIG. 5.

FIGS. 2, 3, AND 4.—PRINCIPLE OF THE RING THROSTLE.

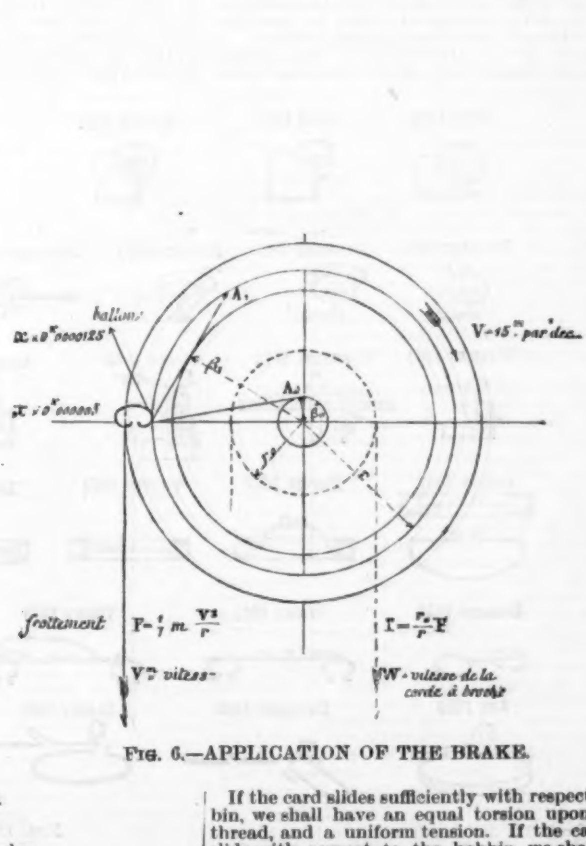


FIG. 6.—APPLICATION OF THE BRAKE.

component 3 produces a negative friction $-\frac{1}{7}$ 3, and the component A a vertical friction $= \frac{1}{7}$ A. It will be necessary that $S = F + \frac{1}{7} A - \frac{1}{7} 3$.

If, then, the traveler be much too heavy, it may happen that A_0 will become too great for the strength of the thread; and, if it be too light, it may happen that its centrifugal force will be exceeded by A_0, and that it will rub against the external edge of the ring with an energy that no thread can resist.

In short, there is a friction of the traveler in the interior of the ring which is advantageous, and an upward friction of the traveler upon the periphery of the ring which is detrimental. Consequently, if it be desired to spin well, it is necessary to reduce the

A_0 = tension of thread.
A_1 = " " "
T = force of brake.
F = resistance of traveler.
$Fv = T\,w$.
$\beta_1 = 6\,\beta_0$ = radius of bobbin.
$r = 7\,\beta_0$
$r = 2\,r_0$

$$A_0 = \frac{r_0}{\beta_0} \times T_0 ;\; A_1 \frac{r_0}{\beta_1} \times T_1 ;\; A_0 = 6\,A_1$$

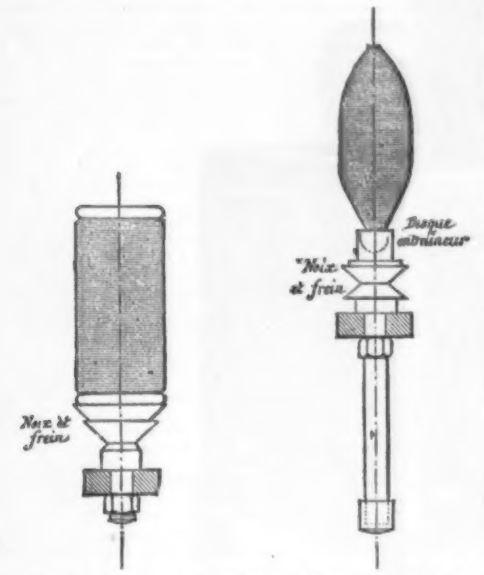
In order that A_0 shall equal A_1, the spindle card must move faster than the bobbin, and the sliding must be in inverse ratio of β_0 and β_1 between the card and

If the card slides sufficiently with respect to the bobbin, we shall have an equal torsion upon the wound thread, and a uniform tension. If the card does not slide with respect to the bobbin, we shall have less tension in the thread wound upon the small diameter, and a tension at least six times greater, at the same instant, than upon the thread wound upon the large diameter of the bobbin.

In the case of a slack card, as the friction in the nut is slight, and as the traveler acts through the tangent thread upon a large diameter, this latter will easily prevent the spindle from revolving; so that upon the large diameter the thread will be less twisted than upon the small diameter of the bobbin.

In the case of a very taut cord, every revolution of winding infers one rotation of the traveler around the spindle; and by reason of this there will be a larger number of revolutions upon a small winding diameter, if it be desired to wind the same length as upon the larger diameter. As it is the number of rotations of the traveler that determines the twisting of the thread regularly paid out, it is evident that the thread will be less twisted upon the small winding diameter than upon the large. From this there result irregularities in the twisting that amount to considerable from one spindle to another, from the moment that the cords are unequally taut.

It may be remarked that the thread is but slightly twisted, and breaks when the spindle cord is slack, and the traveler is heavy enough. It may be remarked, too, that the tension of the thread becomes constant, whatever be the diameter upon which it is wound, from the moment at which we establish a slight friction between the bobbin and the spindle cord, so that the velocity of the traveler remains constant. This is what led Mr. Bourcart to apply the brake shown in Figs. 6, 7, and 8.



FIGS. 7 AND 8.—DETAILS OF THE BRAKE.

It is very difficult to cause the twisting of the thread to proceed above the guides as far as to the delivering rollers. The thread makes an angle, and the guides prevent the twisting from passing beyond, as soon as the thread is somewhat taut. This effect, which is a disadvantage when the spinning and winding is being done upon the small diameter, is useful as a general thing, since it does not prevent the tension from being transmitted. Owing to this, we have as little twisting as we desire between the rollers and thread-guide, and the tension on the thread draws out the irregularities. In this case it is very important to have an equal tension upon the thread, as well as an equal twisting.

The minimum tension transmitted to the roller is given by the centrifugal force of the balloon thread. Admitting that this latter acts like a weight attached to the end of a tangent thread wound upon the spindle, it is evident that it will tend to unwind the tangent thread, and will revolve more quickly than the spindle, until it finds a resistance that balances its tendency to unwind.

In Fig. 9, let us suppose K to be a revolving shaft around which winds a string of several thicknesses, β_0 and β_1. This string passes through a traveler, C, and from it there is suspended a weight, B. The shaft, K, carries a brake, R, to which is attached a weight, T, lifted by friction.

$$B\,V = T\,w, \text{ whatever be } \beta.$$

$$\text{If } w = V\frac{r}{\beta}, \text{ we have } T = B\frac{\beta}{r}, \text{ whence}$$

$$T\,w = B\,V \times \frac{r}{\beta} \times \frac{\beta}{r}$$

This leads to the conclusion that if the tension produced by the balloon be constant, the traveler will have a constant velocity, unwinding the thread of the bobbin, the balloon performing the functions of B, and the traveler of T. If the balloon becomes too small, it will no longer act, the tension of the thread will become excessive, and the thread will break if β is not very large.

When we succeed in producing the above effect of the balloon thread, we have a very simple calculation (Fig. 10), which shows that it is the centrifugal force of the balloon on meeting the traveler which it revolves, and not the tension of the tangent thread. By reason of this, if the balloon be constant, the tension of the tangent thread will be constant likewise. The calculation is as follows:

Let B be the centrifugal force of the balloon thread.

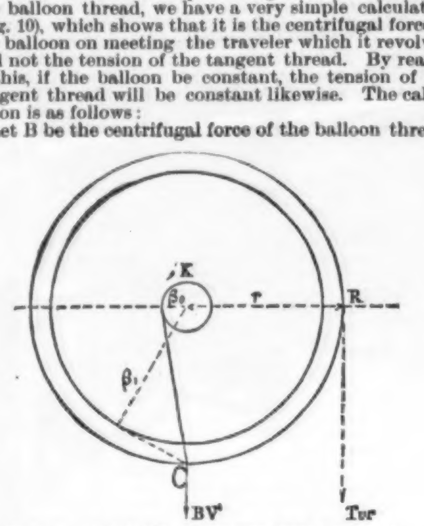


FIG. 9.—APPLICATION OF THE BRAKE.

This will only act about normally to the axis of the spindle, and it will be only the half of its weight that will act. The bobbin thread will have for its tension A_0 and A_1, that is to say, the tension due to the motion of the balloon $\frac{1}{2}\,m \times \frac{V^2}{r} = A_0 = A_1$.

Let F be the friction of the traveler upon the ring due to its centrifugal force, $\frac{1}{2}\,m \times \frac{V^2}{r}$. Let f be the friction of the traveler due to the resultant R_1 and R_0 of B and A.

As soon as $B = F + f$, we shall have $A_0 = A_1 = B$.

As a usual thing, the balloon thread acts otherwise (Fig. 4), because it is not constant, and forms in the traveler quite a sharp angle, which varies considerably.

By repeated experiment, Mr. Bourcart has found that the balloon thread does not always form a sharp angle in the traveler, but that the latter, in certain cases, is situated upon the curve of the balloon thread, so that the balloon tends to revolve it exactly as if it were a weight attached to the tangent thread. This happens especially when the winding is being done with a large balloon and with too light travelers upon a diameter almost as wide as that of the ring. This phenomenon is known to all ring throstle spinners.

Now, by means of a large and constant enough balloon, in connection with a heavy enough traveler, we succeed in entirely overcoming the trouble resulting from a tension of the tangent thread, as compared with the tension transmitted to the balloon thread (Fig. 5). Yet it is impossible to avoid such inconveniences, at the time of setting the traveler and balloon thread in motion, without the aid of peculiar arrangements that are due to Mr. Bourcart, and that we shall describe further along. Mr. Bourcart has found that the friction of the thread in the traveler is 56 per cent. of the tension transmitted, so that, at a certain velocity, the tension remaining the same, and the thread passing through the traveler very swiftly, the tension transmitted becomes almost null. It is likewise to this effect that must be attributed the want of compactness of the bobbins, when the winding is being done with too large a balloon for the traveler used.

We have seen above, from a theoretical standpoint, the pernicious effect of the balloon that destroys some of the valuable advantages of the ring throstle. The greater the velocity of the spindles, and the higher the bobbin, the larger is the balloon at the beginning of the removal. The balloon sometimes becomes so large that it catches the neighboring threads or winds round the point of the spindle. At other times it becomes so small that it is necessary to give an excess of twisting to the thread, if it be desired to prevent its breaking from the slightest accident. Hence, serious difficulties in winding at the beginning and end of removing the bobbins. In order to avoid these, it becomes necessary to reduce the speed of the machine, to increase the torsion, to make the bobbins as short as possible, and to widely separate the spindles, or else form an unequal thread.

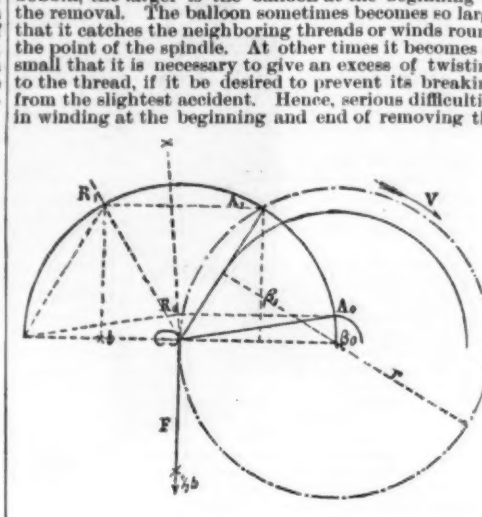


FIG. 10.—APPLICATION OF THE BRAKE.

In his system, Mr. Bourcart obtains a uniform balloon through the application of a movable thread-guide (Fig. 2), that rises with the winding carriage, and parallel with it. This guide might be rendered complete by a rod or simple iron wire situated above and along the rings, and capable of receiving a motion independent of that of the carriage. The object of this guide is to so regulate the tension of the thread that it shall be always equal.

The mechanism of every ring throstle is elementary, and the spindle shown in Fig. 2 gives a good idea of the most interesting part of these machines.

The regulation of the balloon in the Bourcart throstles permits of making longer and larger bobbins; of working more quickly, as the velocity of the bobbins may reach 9,500 revolutions per minute; and lastly, of spinning upon a bare spindle, this being a great advantage, since it is easier to sell thread in the form of bobbins without tubular or wooden cores.

FIG. 11.—TRAVELERS.

Some of the other practical arrangements that distinguish the Bourcart throstle are the following: A momentary arrest of the delivery rollers, in order to tighten the points of the bobbins; a grooved disk that permits of taking off the bobbins without breaking the threads; a spindle with polygonal collar, combined with the spindle of the winder, and the bush of which is very deep; a very rapid twisting of the thread from below upward, produced by the action of springs upon the motion of the ring carriage; and, finally, a

double driving pulley, provided with a brake for arresting the rollers before the spindles, and setting the latter running before the rollers.

Travelers have taxed the inventive ingenuity of manufacturers of these kinds of machines, and some of the principal types that have been devised are shown in Fig. 11. In addition to these, there is quite a large number with rings moved by cords; but all these are so complicated that there is scarcely any practical interest in figuring them here.

The traveler used in the Bourcart throstle is provided with a hook, which permits of a double enveloping of the thread without the spirals touching. By this means we obtain a thread tightly stretched between the traveler and bobbin, and more slackness in the balloon, whence the possibility of making a slightly twisted thread, and, at the same time, of obtaining compact bobbins.

In conclusion, let us see how the various operations are effected in the practice of spinning.

The copping of the thread being secured, whatever be the diameter upon which the winding is done, and that, too, without cutting the thread or stretching it more than is necessary, it is well to study how this copping should be done in order to be well done.

It is necessary (1) that the bobbin shall be handsome; (2) that the thread shall be wound in elongated helices in an upward direction, and in short ones in a downward, so as to have a succession of compact cones set into one another; (3) that the bobbin shall be hard and withstand packing and carriage without being spoiled; and (4) that the broken thread shall be easily found.

If such conditions are not fulfilled, the twists will be

FIG. 12.—BOURCART'S TRAVELER.

bad in spinning upon the spindle with paper cylinders. As for the form of the bobbins, that will be given by any well-regulated winding machine. The bobbins are rendered hard by means of the weight of the traveler and the wide "ballooning" of the thread, along with hard twisting.

To remove the bobbins, the machine is stopped, and the thread-guides are pushed out of the way of the spindles. Then new paper tubes are put in place. The spindles are set in motion before the delivery rollers, and then the copping carriage is raised to the starting point of another removal, the rollers at the same time being set in motion.

The end of the broken thread is searched for by lifting the spindle with the hand slightly above the ring, and stopping the spindle by grasping it. The end of the thread, when found, is with the other hand passed directly into the traveler, and attached to the roller, the spindle being gradually freed.

As regards the starting of these machines, since the spindles slide from 25 to 30 per cent. on passing from a state of rest to that of motion, they are set running first, and the rollers afterward, but not until the spindles are revolving at their normal speed. Conversely, as the spindles slide from 10 to 15 per cent. while running, it is necessary, on stopping the machine, to stop the rollers first and spindles last. Without such precaution, the rollers would deliver unstretched thread during the slipping of the cards, and produce kinks and unevenesses.

The mechanical means for obtaining all these results are found in an embryo state in the throstle frame of Jenk, of America (1829). They have been successively improved by Bodmer (1837), Dodge (1847 and 1849), Vincent (1853), and Johnson (1857), and more recently by Borland and Christie, but without much success. It was reserved to Mr. Bourcart to take up the work of his predecessors, and obtain therefrom a machine which is now absolutely practical and complete.—*Le Génie Civil.*

[Continued from SUPPLEMENT No. 550, page 8782.]

REFRIGERATING AND ICE-MAKING MACHINERY AND APPLIANCES.*

By T. LIGHTFOOT.

4.—*Considerations as to the Applications of the Various Systems.*

UNDER this head it is not intended to deal with the class of apparatus first described—for abstracting heat by the rapid melting of a solid—inasmuch as, excepting for domestic purposes in localities where other ice is not available, its application is wholly special and very limited, being confined almost entirely to the laboratory. Nor in regard to the machinery and apparatus in the second class—for abstracting heat by the evaporation of a more or less volatile liquid—need much be said, so far as ice-making and ordinary cooling are concerned; the various systems have already been explained in considerable detail, and sufficient information has been given upon which to base an estimate as to their economical application under any stated conditions. It is, therefore, chiefly with the machinery described in the third class that the present considerations will deal—namely, machinery by which a gas is compressed, partially cooled while under compression, and further cooled by subsequent expansion in the performance of work.

Probably the earliest application of a refrigerating machine to manufacturing purposes was in 1861,* when one of Harrison's ether machines was used by Mr. A. C. Kirk for the extraction of solid paraffin from shale oil. Since then the manufacture of paraffin has been developed to a large extent, and at the present time there are very few works engaged in its production without a refrigerating machine of one kind or another.* For the cooling of worts and of fermenting beer in breweries, refrigerating machines are largely employed. With English beer, which it is not necessary to cool below 50° Fahr., the general practice is to reduce the temperature of the cooling liquor by passing it through the refrigerator of the machine, the cooled liquor being afterward used in an ordinary brewer's refrigerator. For lager beer, however, which is fermented at about 40° Fahr., the liquor is generally cooled by means of brine, and the temperature is brought down nearly to freezing-point. The same machine is in this country frequently employed for circulating cooled brine through a series of pipes above the fermenting tuns as well as for cooling the liquor; while in lager beer breweries the whole of the fermenting rooms and stores are kept, the former at about 42° Fahr., and the latter at about 31° Fahr., by means of cold brine circulating through pipes placed either on the ceiling or around the walls. For breweries, as well as for paraffin extraction, there can be no doubt that the most suitable machines to employ are those in which the cold is produced by the evaporation of a volatile liquid. Notwithstanding this, air-refrigerating machines have been applied for both purposes in certain special cases, and have given good results, though at a larger expenditure of fuel. There are many instances, however, in which the extra cost of fuel may be more than counterbalanced by the advantages resulting from simplicity and compactness, and from the absence of all inflammable or corrosive chemicals. Besides this, the facility of application of cold-air machines is much beyond that of any other refrigerator. For these reasons they have been applied in dairies and in butterine works; in the latter case an additional advantage is gained from the rapidity with which the cooling can be accomplished, owing to the extremely low temperature at which the air is delivered from the machine.

The most extensive application of dry air refrigerators, however, has been to the preservation of meat and other perishable foods. Explanations with regard to the general question of preservation by cold have already been fully gone into by the author in a paper on the "Preservation of Foods by Cold," read before the Health Congress at Brighton, in December, 1881; and it will therefore suffice here to state that, although it had long been known that at low temperatures the decomposition of animal matter was arrested for an almost indefinite period, yet the practical realization of preservation by cold was prevented from being carried out for want of a simple and efficient means of artificial refrigeration. The attempts that had been made to produce a refrigerated atmosphere by means of ice had not given satisfactory results, owing, no doubt, to the moist state of the air, which, cooled by contact with melting ice, was necessarily saturated, and brought about a musty taste and loss of flavor in the meat preserved in it. In 1878, however, upon the successful development of the cold-air machine, it became possible to produce a cold atmosphere which, even at a temperature of from 35° to 40°, never contained more than from 50 to 60 per cent. of the moisture required to saturate it. Under this condition all danger from excess of moisture as well as from excessive dryness was avoided; and the dry air refrigerator was, therefore, speedily adopted for preservative purposes. Machines in which cold is produced by the evaporation of a volatile liquid have also been applied for preserving perishable foods. This has been done, either by cooling the rooms direct by means of overhead pipes through which the cooled brine is circulated, or else by causing a current of air from a fan to impinge against surfaces cooled by an internal circulation of brine, and by then passing the cooled air into the storage rooms. As to whether the air machine or that employing a volatile liquid is the best and most suitable, no general rule can be laid down. The simplicity, compactness, and readiness of application of the air machine have secured it a ready adoption in many cases where chemical machines would have been wholly inadmissible; but on the other hand the author considers that air machines have frequently been entirely misapplied. For use on board ship there can probably be no difference of opinion; and nearly the whole of the meat now imported into this country in a cooled or frozen condition is preserved by means of dry-air refrigerators, while in only one or two cases is a portion of it chilled and frozen on land by chemical machines.

The means adopted for the freezing and preservation of meat are very simple. They consist in lining the room, or the hold of the vessel, with material as impervious to heat as practicable. The construction of the lining is altered in different cases according to circumstances and to fancy; but it may be taken that an outer and inner layer of tongued and grooved boards 1 inch or 1¼ inch thick, with a nine inch space between filled with charcoal, form a fairly good protection, while in some cases silicate cotton may be used with advantage instead of charcoal. A little extra care and expense bestowed on the insulation of a chamber are soon repaid, for when the contents of the chamber are once reduced to the required temperature, the refrigerating machine has nothing further to do than to neutralize the heat passing through the walls, so that, the more perfect the insulation, the greater is the saving in fuel, in wear and tear of machinery, and in attendance. The cold air from the machine is usually admitted by ducts placed near the ceiling, and after performing its cooling work it is led back to the compressor, to be used over again, with the addition of a small amount of fresh air. In freezing, a temperature of about 10° Fahr., or even lower, should be maintained, and the carcasses should be hung so that the air can circulate freely around them. If, however, the meat has previously been frozen, as is generally the case with the cargoes brought from abroad, which are to a large extent frozen on shore, the carcasses are best packed as close together as possible, taking care to avoid injury through bruising, and to see that a free space is left for the cold air to circulate between the meat and the inner lining of the chamber. The temperature in this case need only be maintained low enough to leave a sufficient margin in case of the machinery having to be stopped for any slight adjustment, or for oiling. The capacity of a machine to be applied in any given case is determined by a consideration, first, of the cooling work to be performed on the material contained in the chamber; and, secondly, of the amount of heat that will pass into the chamber from without. With regard to the first, nothing need be said here. The second quantity depends upon the area of the walls, floor, and ceiling, their construction, and the difference between the minimum internal and maximum external temperature. Experience has, of course, laid down certain general rules; but there are always special cases arising which require special treatment, and which can only be considered on the basis here set forth.

The trade in frozen meat has already necessitated the establishment of large stores, where the carcasses are received and kept until they are required for consumption. A number of retail butchers also are now adopting cold stores of their own; such a storage arrangement is carried out in the vaults in Leadenhall Market for the preservation of about twenty tons of meat, partly frozen and partly unfrozen. A vertical dry-air machine is driven by an Otto gas engine, and by working from three to six hours per day supplies sufficient cold air for the four chambers. The temperature rises a few degrees during the night, and between Saturday night and Monday morning; but this is not found to be any disadvantage, and it has never yet been necessary to run the machine on a Sunday. The same water that is used for cooling the air cools also the gas-engine cylinder, and is afterward used for heating the offices. The cost of the gas in this case is 1s. 3d. per hour. In view of the increasing demand for installations of this kind, the author has made arrangements with Messrs. Crossley Brothers to manufacture his dry-air machine in combination with the Otto gas engine, the gas engine simply taking the place of the engine there shown. In this way the cost will be reduced; and space also, which is generally very limited, will be saved. Similar installations have been erected for poulterers, game dealers, and butter salesmen, but need not be further referred to. In addition to the importation of dead meat, refrigerating machines of the horizontal kind shown in the diagrams have been applied for supplying fresh cool air for the ventilation of ships' holds in which live cattle are carried. In this way a temperature of 100° Fahr. has been reduced to 70° in the height of summer, and the loss of cattle has been entirely prevented. No doubt the same system could be equally well applied for the cooling and ventilation of buildings; but so far as the author is aware, it has not yet been tried.

There are also arrangements on board passenger vessels for making ice, preserving meat, game, fish, and other perishable foods, cooling water, preserving vegetables, and cooling wine, beer, aerated waters, etc. This is a plan frequently carried out in large passenger vessels, and was introduced, the author believes, by Mr. Manuel, the engineering superintendent of the Peninsular and Oriental Company. The particular arrangement illustrated is one adopted in connection with a vertical steam-driven machine. The course of the cold air is indicated by arrows. In case of the vegetable room becoming too cold, ducts are provided by which the air can be led direct from the meat chamber to the machine. A somewhat similar arrangement of refrigerating plant is used in hotels; and the author's machines have been successfully applied for this purpose in the United States, though not as yet in this country. A recent application, also worthy of notice, is for preserving fish on board steam trawlers and on shore. Last year two of the author's vertical machines were supplied for this purpose, one on a steam trawler, and one on a carrier, for use off the coast of Brazil, almost under the equator, in a climate where fish was hardly known as an article of diet, owing to the previously insuperable difficulties of preserving it in a sufficiently fresh state.

The fish as soon as caught are placed on trays in an insulated room maintained at a temperature of about 35° Fahr. The experiment has been perfectly successful, and a further order for similar machinery is now being executed. In 1882 dry-air refrigerators were first applied to the cooling of chocolate by Messrs. J. S. Fry & Sons, of Bristol, who adopted one of the author's horizontal machines with the double-expansion arrangement described in his previous paper. Since then a number of similar machines have been applied for the same purpose in different parts of Europe and in the United States; and works which had to be entirely stopped in summer are now carried on during the whole year. The preservation of yeast, the cooling of gelatine dry plates, of fresh-killed meat in slaughter-houses, and the freezing of tongues in South America for exportation, have all been satisfactorily accomplished by the dry-air machine.

A rather remarkable application of refrigeration was made toward the close of last year by Captain Lindmark, of the Swedish Royal Engineers, who was engaged in the construction of a tunnel for foot passengers through a hill in Stockholm, on the top of which were built residential houses. The workmen came upon some ground, consisting of gravel mixed with clay and water, which had so little cohesion that the ordinary method of excavation had to be abandoned and the works stopped, owing to a subsidence in the earth above, which endangered the safety of the houses. Underpinning was out of question, on account of the great expense. Under these circumstances it was decided to freeze the running ground, and to use cold air for the purpose as being most readily applied. One of the author's horizontal machines, capable of delivering 25,000 cubic feet of air per hour, was accordingly supplied by Messrs. Siebe, Gorman & Co., and was erected in the tunnel as close as possible to the required spot. The innermost end of the tunnel next the face was formed into a freezing chamber by means of partition walls, which were made of a double layer of wood filled in between with charcoal. In the middle of last September the works were resumed. After the refrigerator had run for sixty hours continuously, the gravel was frozen into a hard mass to a depth varying from 5 feet near the bottom of the tunnel to 1 foot near the top. At the crown no freezing took place, and, though the temperature at the bottom of the chamber was as low as 40° below zero Fahr., a thermometer placed at the top, 16 feet above the floor, indicated, 32° above zero. This circumstance, however, was an advantage rather than otherwise, because, in any case, the roof would have had to be supported by planking, which would have been difficult to drive into the gravel had it been actually frozen at that part. The work was proceeded with in lengths of 5 feet, the excavation commencing

* A paper read before the Institution of Mechanical Engineers, May, 1886.

* Full information in regard to the most recent practice in paraffin cooling will be found in the *Journal of the Society of Chemical Industry*, May 29 and November 30, 1885, which contains papers by Mr. Beilby, describing the cooling machinery erected at the Oakbank Oil Works.

at the top; and a temporary iron wall made up of plates 12 inches square was built in against the face from the top downward as the cutting away of the gravel proceeded. From eight to ten feet up from the bottom no protection was needed, as the frozen gravel formed such a hard, solid mass that it had to be removed with special tools. After once fairly starting, it was sufficient to run the cold-air machine, on the average, from ten to twelve hours every night, excepting after heavy rains, when much water percolated through the gravel. The machine worked all the time without a single hitch, and delivered the air at a temperature of 67° below zero Fahr. The temperature of the freezing chamber was generally from 6° to 15° below zero Fahr. after twelve hours' running; but it soon rose to freezing point when the men began to work. After two five-foot lengths had been excavated, the partition wall was removed forward; the capacity of the freezing chamber thus varied from 3,000 to 6,000 cubic feet. The arching of the tunnel was completed as rapidly as possible close up to the temporary iron wall, while the ground was still frozen. This method of driving the tunnel was employed through a distance of about 80 ft. with entire success. In the residential house to the north, neither subsidence nor cracks were perceptible three months after the tunnel was completed at this point. In the house to the south, the front has subsided about an inch, causing some small cracks in the walls; but this house was not so well built as the other, subsidences having taken place in it before the tunnel was commenced. The daily progress while using the freezing process averaged about one foot. Although this is the first instance in which a dry-air refrigerator has been applied for the freezing of running ground, it is not the first in which refrigeration has been used for that purpose. As early as 1862 an ether machine was constructed by Messrs. Siebe, Gorman & Co., for freezing a quicksand met with in sinking a well. In that case, pipes formed into a coil of larger diameter than the lining of the well were sunk into the quicksand, which was then frozen solid by circulating cold brine through the pipes. The excavation was then proceeded with, the lining put in, the circulation of brine stopped, and the coil removed. The same plan has recently been adopted by Mr. Poetsch in Germany in connection with the sinking of colliery shafts; but instead of a coil a series of vertical iron pipes are used, arranged in a circle, the effect of course being precisely the same. For driving the Stockholm tunnel, however, it is difficult to see how freezing by means of brine could have been applied, the excavation being horizontal instead of vertical.

TABLE I.—*Freezing Mixtures.*

Composition by Weight.		Reduction of Temperature in Degrees Fahrenheit.
Ammonium nitrate	1 part	From + 50° to + 4° = 46°
Water	1 "	
Ammonium chloride	5 parts	From + 50° to + 10° = 40°
Potassium nitrate	5 "	
Water	16 "	
Ammonium chloride	5 parts	From + 50° to + 4° = 46°
Potassium nitrate	5 "	
Sodium sulphate	8 "	
Water	16 "	
Sodium nitrate	3 parts	From + 50° to − 3° = 53°
Nitric acid diluted	2 "	
Ammonium nitrate	1 part	From + 50° to − 7° = 57°
Sodium carbonate	1 "	
Water	1 "	
Sodium phosphate	9 parts	From + 50° to − 12° = 62°
Nitric acid diluted	4 "	
Sodium sulphate	8 parts	From + 50 to 0° = 50°
Hydrochloric acid	9 "	
Sodium sulphate	5 parts	From + 50° to + 3° = 47°
Sulphuric acid diluted	4 "	
Sodium sulphate	6 parts	From + 50° to − 10° = 60°
Ammonium chloride	4 "	
Potassium nitrate	2 "	
Nitric acid diluted	4 "	
Sodium sulphate	6 parts	From + 50° to − 40° = 90°
Ammonium nitrate	5 "	
Nitric acid diluted	4 "	
Snow or pounded ice	2 parts	To − 5°
Sodium chloride	1 "	
Snow or pounded ice	5 parts	To − 12°
Sodium chloride	2 "	
Ammonium chloride	1 "	
Snow or pounded ice	24 parts	To − 18°
Sodium chloride	10 "	
Ammonium chloride	5 "	
Potassium nitrate	5 "	
Snow or pounded ice	12 parts	To − 25°
Sodium chloride	5 "	
Ammonium nitrate	5 "	
Snow	3 parts	From + 32° to − 23° = 55°
Sulphuric acid diluted	2 "	
Snow	8 parts	From + 32° to − 27° = 59°
Hydrochloric acid	5 "	
Snow	7 parts	From + 32° to − 30° = 62°
Nitric acid diluted	4 "	
Snow	4 parts	From + 32° to − 40° = 72°
Calcium chloride	5 "	
Snow	2 parts	From + 32° to − 50° = 82°
Calcium chloride crystallized	3 "	
Snow	3 parts	From + 32° to − 51° = 83°
Potash	4 "	

TABLE II.—*Evaporation of Liquids.*

Liquid or Gas.		Water.	Anhydrous Ammonia.	Sulphuric Ether.	Methylic Ether.	Sulphur Dioxide.	Pictet's Liquid.
Specific gravity of vapor, compared with air = 1·000		0·622	0·59	2·24	1·61	2·24	—
		Fahr.	Fahr.	Fahr.	Fahr.	Fahr.	Fahr.
Boiling point at atmospheric pressure.		212°	−37·3°	96°	−10·5°	14°	−2·2°
Latent heat of vaporization at atmospheric pressure.		966°	900°	165°	—	182°	—
	Fahr.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Absolute vapor tensions in pounds per square inch at different temperatures.	−40°	—	—	—	—	—	—
	−20°	—	19·4	—	12·0	5·7	11·6
	0°	—	30·0	1·5	18·7	9·8	15·4
	+20°	—	47·7	2·6	28·1	16·9	22·6
	+32°	0·089	61·5	3·6	36·0	22·7	27·0
	+40°	0·122	73·0	4·5	42·5	27·3	31·3
	+60°	0·254	106·0	7·2	61·0	41·4	44·0
	+80°	0·503	152·4	10·9	86·1	60·2	60·0
	100°	0·942	210·6	16·2	118·0	84·5	79·1
	120°	1·685	283·7	23·5	—	117·5	99·7
	140°	2·879	—	33·5	—	—	—
	160°	4·731	—	45·6	—	—	—
	180°	7·511	—	62·0	—	—	—
	200°	11·526	—	81·8	—	—	—
	212°	14·7	—	96·0	—	—	—

Colonel Martindale said that in the year 1881 the London and St. Katherine Dock Company, of which he had the honor to be the general manager, were pressed by some of their Australian friends to make arrangements for receiving frozen meat and storing and distributing it. They necessarily began on a very small scale. They had a large vault under one of the warehouses about 500 feet long and 64 feet wide, divided originally into four compartments. They made use of it for their storage. They commenced with a small engine, delivering 10,000 cubic feet of air per hour, from Messrs. Hall, of Dartford, and it did excellent work until 1884, when it was removed to make room for a larger one. They now had fifty-six chambers in two vaults. The smallest had a cubic content of 2,273 feet, the largest 9,280 feet, and the total content of the fifty-six chambers was more than 183 cubic feet. The carcases averaged in weight 56, 60, and 72 lb., and if the chambers could be completely filled they would hold about 59,000 sheep of the first weight, 56,000 sheep of the second weight, and 44,000 sheep of the third weight, but in practice space had to be left to separate different marks and for gangways. A proportionate deduction, therefore, had to be made from what they could otherwise store; still they could always store forty-four thousand sheep of the largest size. The construction of the chambers had varied a little in detail, but the last that had been built was according to the recommendation of Mr. Haslam, of Derby. There was a 1¼ inch boarding of rough boards on a concrete floor, and 4 inch bearers, at about 20 inches apart, to carry the floor, which was in two thicknesses of 1¼ inch boards, with prepared brown paper between them. The intervals were filled with carefully dried charcoal. The sides and roofs were similar in construction, and the whole of the boards were grooved and tongued. Air was conveyed by wooden trunks from the machines into the chambers, and pumped into them by slides in the trunks, the air coming in at one end close to the roof, and being drawn in at the other end also close to the roof. Most of the chambers were fitted with return air trunks, which had to be cleared out every twenty-four hours, and the engines' snow boxes about every four hours. A great loss of cold was experienced at every angle, and therefore all rises or falls should be conducted through sloping trunks. A properly insulated air chamber would not rise more than from 24° to 25° in twenty-four hours if the engines were stopped. They had at present four of Haslam's 60,000 feet machines and three of Hall's 30,000 feet machines. They were supplied with steam from the three multitubular boilers of the marine type and four boilers of the locomotive type. If they had to start afresh, they would not have any boilers of the locomotive type. They had had to feel their way step by step, and the trade had grown upon them. At the A jetty stores, a Haslam 60,000 feet machine was worked on 16 chambers of a total capacity of 48,000 cubic feet, capable of storing 11,000 sheep of the average weight of 72 lb., but allowing for gangways, divisions, and marks, that 11,000 had to be reduced to 8,000 or 9,000. The engine was running twenty out of the twenty-four hours, the four hours' stoppage including the necessary time for clearing the valves, snow-boxes, and air-trunks. The average speed was 80 revolutions per minute, at an air pressure of 44 lb. per square inch, giving a temperature of 57° below zero in the snow-boxes, and keeping the chambers down to a temperature of from 15° to 18° Fahr. In practice that was found to be about the best temperature at which to keep the meat. About 4½ tons of coal were used in the twenty hours. They had found that it gave better results in proportion to fuel to work at a pressure of 40 lb. to the square inch, instead of 50 lb. and upward. In keeping such a low temperature in the snow-boxes, a greater volume of cold air was delivered into the chambers, when the proportionate loss in temperature was much less between the delivery from the expansion cylinder to the distant chambers. At the same jetty they had two of Hall's 30,000 feet machines working in fifteen chambers of the same capacity, and doing just about the same work. At the B jetty there were two of Haslam's 60,000 ft. machines working on twenty-four chambers of 90,000 cubic feet capacity, and running at an average of 70 revolutions per minute, with an air-pressure of 40 lb. per square inch, a temperature of 55° below zero in the snow-boxes, and a coal consumption of 4½ tons in the twenty hours. The loss of temperature in the delivery of air to the chambers at any distance was generally considerable. As a rule the chamber next to the engine was kept at a sufficiently low temperature without opening the delivery ports in the air trunks. The air was delivered into the next chamber at about 9° Fahr., and into the most distant chamber, 165 feet from the engine, at from 16° to 18° Fahr. The greatest care ought to be taken in regulating the delivery and return air ports, gradually increasing the area in both in proportion to the increased distance. The greatest distance that the air was run was 180 feet. When the temperature of the nearest chamber was at 9° Fahr., they found the most distant chamber was at 18°, and therefore the loss in temperature in traveling was 1° for every 18 feet or 20 feet traveled. He did not want the Institution to take that as a scientific result, but it was the practical result of the observations taken by the officers of the company extending over some time. Ninety hundredweight of coal worked the three engines, giving out nominally 120,000 feet per hour for twenty hours. That reduced would give 2 lb. of coal required for every 240 feet of air delivered; but in practice they would have to rather increase that amount, because he did not believe the engines actually delivered the total quantity of air that was stated. The coal was ordinary Welsh coal, at about 16s. 6d. per ton. It was also found that from 1 foot to 1½ feet of air per hour would keep cool, say at 18° Fahr., 1 foot of storage at a distance not exceeding 180 feet, or at an average distance of 90 feet. The result that he first arrived at was that one foot of air would keep one foot of storage cool per hour, and Mr. Haslam had arrived at exactly the same conclusion, but allowing for delivery openings and doors, etc., he did not think they could put the quantity of air required at much under 1½ ft. per hour for every foot of storage that they wished to keep down to 18°. If the meat was to remain undisturbed and in large measures, they would probably be able to do with one foot of cool air for every foot of storage.

A communication was then read from Mr. Colyer, in which he stated that one of the first machines made on Mr. Harrison's system was still at work at Messrs. Truman, Hanbury & Co.'s brewery, and was acting very efficiently. It had been there for about thirty years. He thought the consumption of coal actually stated in the paper at 2 lb. per hour was too low, and that 3 lb. or 4 lb. would be nearer the mark. Machines for carrying water and making ice might be divided into two classes: one in which ether was used, and one in which ammonia was used. In London, where coal was dear, and water often had to be obtained from the water companies, the ether system was far more expensive than the ammonia system.

Mr. Gorman said that the machine at Messrs. Truman's was made by the late Mr. Siebe, and was the first made under Mr. Harrison's patent, except the one that was taken to Australia.

Mr. Harrison said the latent heat of ammonia was set down in the paper at 900°, and the latent heat of sulphuric ether at 165°, but the practical working latent heat of ether in the ice-making process was 656°, instead of 165°. The figures given by Mr. Lightfoot were correct as regards equal weights of the different substances at the atmospheric pressure, but the ice maker dealt with measures of capacity. A vacuum pump was a measure of capacity, and to apply the latent heat of equal weights to the quantity passed by a pump was of course altogether inaccurate. Then, again, the ice maker did not work at the atmospheric pressure, and all vapors which were used under lower pressure were of greater latent heat. Latent heat was increased in proportion to the tenuity of the vapor, and if the ice maker worked at a temperature above the atmospheric pressure, there must be a deduction for latent heat lost. In that way the latent heat of ammonia had to be reduced from 900° to 845°, because in using ammonia they worked at a pressure in excess of the atmospheric pressure. There were other points connected with the temperature of condensation, which, in his opinion, brought ammonia and ether very nearly on a level. In point of fact, he thought that of all the different refrigerating agents there was no one better than another. If in any case one seemed to be more efficient than another, it was simply because the principle had been better carried out in that process.

Mr. Price Williams said he had recently had an opportunity of examining the refrigerating process on his voyage out to Australia, and he must bear testimony to the admirable way in which it served its purpose. In this country the question of refrigeration for the preservation of meat was really becoming one of very great importance. In a letter to him not long ago, Sir William Armstrong drew a picture of what a terrible thing it would be for this country if the freedom of navigation were destroyed, and if England lost the supremacy of the sea even for one day. Australia was now able to send any amount of food that could be taken here, but it was regarded as a great mistake to freeze the meat. It seemed to be considered that the arrangement must be such that the meat should not be reduced to freezing, but should be kept as near to the freezing point as possible. As the refrigerating process had been carried out successfully in ships' holds for purifying the air when live cattle were imported, he thought it might be of very great advantage at times to the berths on board ships.

He made an estimate, and the engineer agreed with him, that by the expenditure of the small sum of £700 on board the vessel in which he went to Australia, a constant temperature of 60° or 70° might be maintained. If the P. and O. Company would carry out that suggestion, they would add very largely to the comfort of their passengers, and induce people to make journeys to the torrid zone much more frequently than they did now.

Mr. Halpin said that when once the chamber was got down to the temperature it was desired to run at, of course all the machine then had to do was to overcome the leaks of heat being transferred through the walls. The importance of the covering was therefore very great, because a large amount of power and coal was being used. He had lately made some experiments in Germany with cork as a non-conductor. The French had used that material for many years before, and brought it out in the 1878 exhibition; but the trouble in the French arrangement was the expense. They took the ordinary cork, and cut it up in slices, and got a good effect, but at very great expense. In Germany, however, all the refuse and waste cork was ground into powder and cemented together again, and it made an exceedingly cheap material. The broad results of his tests were that 92 or 93 per cent. of the transfer of heat was totally arrested; in other words, that only 7 or 8 per cent. of the heat went through.

Colonel Martindale wished to add that if chemicals

were used in producing the cold, it was an absolute necessity that the air delivered should not have the faintest trace or smell of chemicals. No consignee would keep his meat in any store where he could detect the slightest smell of that kind.

Mr. Schönheyder said that the cold air was admitted near the ceiling of the chamber, and the hot air was also taken away near the ceiling. It seemed to him that if, in these cold air machines, there was any chance of snow getting in with the air, it had a great opportunity of doing so when it was admitted near the ceiling, and of falling on the meat and possibly deteriorating it. The air might just as well be admitted near the floor. It would then gradually rise as it picked up heat from the carcasses, and could be extracted from near the ceiling.

Mr. Lightfoot, in reply, said that the snow difficulty had never arisen. He had never found the snow fall on the meat, and if the meat was frozen he did not think it would matter if the snow did fall on it. He did not agree with Mr. Price Williams, but thought that the meat must be frozen. Unless it was frozen, decomposition would take place

It might be kept at a temperature of 35° for three weeks, but beyond that time it was impossible, because a slow process of decomposition and of chemical change took place, and the simple question was how much of that could be allowed before the meat was eaten. On the other hand, when the meat was frozen no chemical change of any kind took place. There was a slight mechanical change, and the cellular tissue was to some extent destroyed, and consequently when the meat was thawed there was a loss of juices.

THE INVISIBLE PHOTOGRAPHIC IMAGE.

By W. H. HARRISON.

IT may not be out of place, after the long lull in the consideration of the disputed question of the nature of the developable photographic image, to revive the problem once more, since there is the possibility of more knowledge, from various sources, being now within reach upon the points at issue.

In all, or nearly all, photographic text books, the presumed circumstance of the incessant motions of the molecules of the haloid salts of silver, and of the minor motions between the atoms of the molecule, are not taken into account. Yet, if the generally accepted modern hypothesis of the constitution of matter be accepted as true, no theory of the nature of the invisible image can be of value, without it enters into the question of the influence of the wave-motion of the interstellar ether upon the moving atoms of substances. The ideas now prevalent are, that in a solid body the molecules are swinging to and fro, but with what kind of a motion is not supposed to be known. When waves of heat beat against the solid, the molecules are driven further apart; they roll over each other somewhat as marbles roll over each other in a moving box; in this condition the substance is said to be in its liquid or molten state.

By the application of more heat, the molecules acquire greater freedom still; they then break loose still more; they fly from side to side of the vessel containing them, and the substance is said to be in its gaseous state. When a bladder with a little air in it expands under the receiver of the air-pump, the scientific mind pictures the sides of the bladder as driven outward by the incessant bombardment of the little particles shooting to and fro within, and clashing against each other when they meet. Mr. Crookes, by means of his experiments in high vacua, can so far exhaust a glass globe that even his radiometer vanes will not turn in it under the action of light. In such vacua the material particles left are so few, that it is believed they can travel long average distances, amounting to considerable fractions of an inch, without striking against each other; he even thinks that in some cases the molecules can travel several feet without a collision. By means of metallic reflectors inside these tubes, he can send the molecules in fixed directions and bring them to a kind of a focus; at such a focal point, if they beat against a piece of platinum wire, they make it red hot.

The proof of the truth of the wave theory of light is almost crushing, and some of the best evidence on this point was contained in the experiments on interference recently exhibited by Mr. Darker before the London and Provincial Photographic Association.

Some ten or fifteen years ago the ideas as to the motion of molecules were not so generally accepted as at present, but no better hypothesis for practical use can be found, and it serves to explain observed phenomena. As Professor Tyndall once put the point, light being admitted to be wave-motion, what starts it? If you will follow an aerial sound-wave, you expect to find the vibrating tuning fork, or vibrating tongue of the organ pipe, or other moving source of sound; in like manner, if you follow up the wave of ether, you should expect to find the vibrating molecule at the other end. After tracing a wave of ether to its source, it is not probable that source will be discovered to be a metaphysical abstraction or an algebraical theorem. These ideas of his I quote from memory only; they were made, if I remember rightly, at the meeting of the British Association at Liverpool.

The hypothesis is that when the molecules vibrate in periodic harmony with the waves of ether, their motion is increased; and, supposing the waves of ether to be luminous, the substance so receiving them is visually opaque to those rays which impart such motion. When, however, the waves are not synchronous, they pass round the molecules, and the substance is transparent. No difference but that of wave-length is recognized between waves of radiant heat and of radiant light, the apparently great difference to the human senses being due to the fact that the nervous apparatus of the human eye is so constructed as to be sensitive only to a limited portion of the rays of the spectrum. A strong solution of iodine in bisulphide of carbon is opaque to light, but transparent to those rays of dark heat which silver atoms so readily absorb; hence the strong tendency of the rays of the whole spectrum to set up a motion of separation between the atoms composing molecules of iodide of silver, thus forming, I think, the invisible photographic image upon that salt.

Professor Tyndall often filters out the visible portion of a converging beam of rays from the electric lamp by means of a trough containing a solution of iodine in bisulphide of carbon; but the dark heat rays come to a focus on the other side, the same as before the visible rays were cut off, and brown paper can be ignited in the open room in the invisible focus of the rays of dark radiant heat.—*Br. Journal.*

A NEW OXYGEN AND HYDROGEN REGULATOR FOR THE LANTERN.

AT the "Technical" meeting of the Photographic Society of Great Britain, on the 23d of February, Mr. J. Beard exhibited an automatic regulator for compressed gases, to be used in working the lime light, our notice of which in the report of that meeting was necessarily brief. We are now in a position to describe it at greater length, premising that if gas bottles containing compressed gases could be used in place of gas-bags, a boon and blessing would be conferred upon photographers and lantern exhibitors.

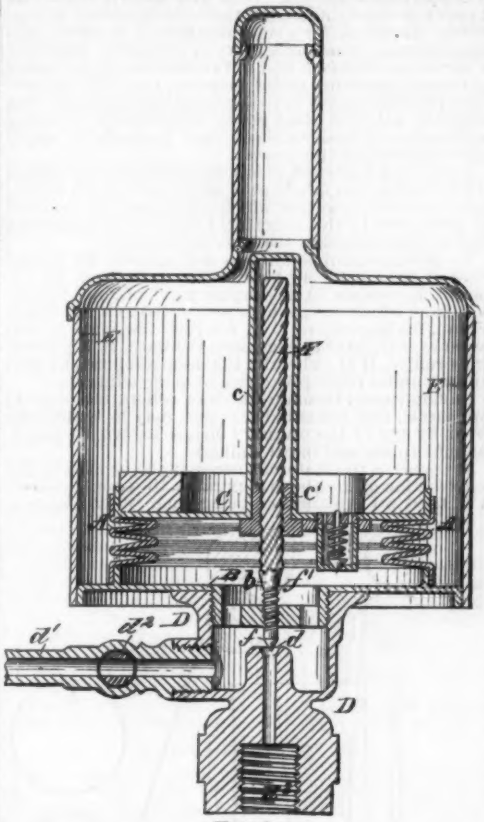


FIG. 1.

Compressed gas in bottles has not hitherto generally been adopted, in consequence of the trouble to regulate the ever decreasing pressure. Although bottles have been made to contain from seven to fifty feet, and, being made of steel, have been compressed to even 3,000 lb. pressure upon the square inch, it was impossible to use them with success, unless a valve or regulator was supplied to give off the gas just as required.

This at last is done, and Messrs. Oakley & Beard, of Bermondsey, have patented a governor, which we saw at work on the occasion referred to, and which unquestionably will raise the standard of lime light exhibitions, and give a portable and easy way of storing the gases and using the lime light.

In London and large towns compressed gases (oxygen and hydrogen) are kept in stock in bottles of various sizes, from 600 lb., or 40 atmospheres, to 3,000 lb., or 200 atmospheres. Of these the lowest pressure is the best, as there is not the waste in use or handling, and the valves do not require to be screwed down with such force. A ten-foot bottle occupies about one-fortieth the space of a ten-foot bag and board, and is only one-fifth the weight. Of course, only a single lantern can be used if a mixed jet is required. If with a blow-through jet, fair dissolving can be obtained; but not *effects* proper, such as snow falling, swans swimming, etc., which require two jets full on for a longer time than dissolving one picture into another. The Oakley governor has only to be screwed tightly upon the neck of bottle, and connect the rubber tube in the usual way to the jet or dissolver or jets (as many as required), and turn on valve at bottle full, and the pressure is checked by the automatic valve spindle, and the gas will be given off as from a bag, or exactly as required (no tying of valve required). The governor is weighted to a twelve-inch water pressure, or equal to twice as much as the ten-foot bags with three half-hundredweights.

Fig. 2.

The action of the regulator will be understood by reference to the sectional diagram, in which A A is a circular bellows of the finest rubber; B is the base plate to which it is attached; C, the movable head to which it is also attached; D is the casting that fits the neck of the bottle at d^3, which carries at its center a valve seat, d, and has projecting from it laterally a delivery pipe, d^1, fitted with stop tap, d^2. The movable head, C, is fitted with a central tube, C', closed at its upper end; at its lower end a nut is fixed, C^2, which is threaded internally to receive a quick screw, F. This screw forms the spindle of regulating valve, f, which fits the valve seat, d, made in the casting, D. Immediately above the valve a slow thread, f^1, is cut on the valve spindle, and in the neck of base plate, B, a thread is cut to correspond with the thread, f^1 on valve spindle; openings are made in this neck for the passage of the gas into bellows, and as the pressure of the gas varies, the bellows will be caused to expand or contract, the tendency of the weighted head, C, being to force the bellows into the compressed state. As the weighted head descends it will impart an axial motion to the valve spindle, and thereby cause the valve under the action of the screwed neck, b, to recede from its valve seat, and thus enlarge the opening for the delivery of the gas. When the pressure of the gas is in excess, the weighted head will rise and give an axial motion in the opposite direction, and force down the valve toward its seat. By this means a perfect automatic regulator of the delivery is effected. E E is simply a metal casing for protection. Thus this regulator will supply one jet or twenty, and from only one bottle, automatically, as required, without touching the taps.

Those who refer to our report of the meeting in question (page 135, *ante*) will find that the subject of the ethoxo light was also under discussion. We are glad to find that Messrs. Oakley have successfully adapted their regulator to this light, as will be seen from the following diagram and description (Fig. 2):

The jet in the drawing is a safety mixed jet, to be used with ether or otherwise. This jet is very perfect, and was given to Messrs. Oakley by the Rev. T. F. Hardwich, who has devoted so much time and trouble to go thoroughly into the subject, and test scientifically the safety of jets, of which form this was the result of their labors. We will not go into description here, as a full account was given of its make and trials in this *Journal* of April last year, pages 248-9. The ether tank is also constructed as therein described. The oxygen in Hardwich's tank does not pass through the ether, but simply over it, snake fashion, and becomes saturated with the vapor of same.

A, bottle of oxygen; B, tap on bottle; C, T-piece to connect gauge (D) and regulator (E), that exact amount of gas can be seen remaining in bottle during working; D, pressure gauge; E, Oakley & Beard's patent automatic regulator, with stop tap, F; G, rubber tube connecting regulator to ether tank, which passes a portion of oxygen on to O, tap of jet, and a portion into tank at H, tap, which passes over the top of ether, and passes out saturated through tap, K, through rubber tube, M, to other tap, N, of jet; R is simply time cylinder, P is Hardwich's safety jet chamber.

Thus, it will be seen, a portable and safe apparatus will be before us in the future.—*Br. Jour. of Photo.*

PHOTOGRAPHY WITHOUT AN OBJECTIVE.*

By Dr. M. BOUDET.

IN a communication to the International Society of Electricians, on the third of March last,† I showed that the actinic properties of the electric effluvium permit of photographically reproducing any plane object whatever that is simply laid upon a plate prepared with gelatino-bromide of silver. I added that the reproductions thus obtained became much sharper and intenser when the effluvium is reflected by a plane mirror serving as a support to the photographic plate. The effects produced by a reflected electric glimmer prompted me to make some more researches, and the results of these I have the honor, to-day, to submit to the Academy.

A gelatino-bromide plate is placed flat upon a plane mirror, sensitized side upward. Upon this sensitized surface we place the design or photograph that we wish to reproduce; and in order to prevent any effect of transparency, we place over all a very thick card, or, better, a piece of blackened paper. Then we cover with a pane of common glass, in order to keep things in position. Afterward, we make an exposure for a few seconds to the light of a Carcel lamp at a distance of 9 or 10 inches, and incline the mirror in different planes so as to permit the luminous rays to penetrate obliquely under all points of the object to be reproduced. Finally, we develop the negative, and fix it in the usual way.

The negatives obtained by this process, and presented with this note, sufficiently prove that a drawing, a photograph, or any plane object whatever, can be reproduced photographically *without the aid of ordinary apparatus, and with the light of a Carcel lamp.*

Numerous experiments, repeated in every form, have demonstrated to me that the impressing of the silver bromide occurs without the use of apparatus with lenses, provided the light be *reflected.*

I have never been able to do anything with direct light.

I have thought that these easily repeated experiments might interest physicists, and I should be glad if they could serve as a starting point for more important scientific researches.

A WRITER in the *Bee Journal* says that bees have a strong antipathy to dark-colored objects. A brood of chickens ran about his hives. The bees stung one of the dark ones to death, and did not molest the light-colored ones. He says that a man with a black plug hat rarely gets stung, the bees devoting their entire attention to shooting the hat.

* Note presented to the Academie des Sciences by Mr. Lippmann, April 5, 1886.

† See SUPPLEMENT, p. 8649.

WATER-PROOF PAPER.—PARCHMENT PAPER.—TOUGHENED PAPER.—DISSOLVED PAPER.—PAPER SLABS.—PAPER LUMBER.—PAPIER MACHE.—PAPER BUTTONS.—HARDENED PULP.—PAPER LEATHER.—LEATHEROID.—WATER-PROOF PAPER BAGS.—CELLULOSE.—CELLUVERT.—VULCANIZED FIBER.—ARTIFICIAL IVORY.—ARTIFICIAL HORN.

By the chemical treatment of paper pulp, fine woody fiber, a cellulose, or vegetable fibers of various kinds, from which paper is ordinarily made, certain useful qualities, different from those belonging to common paper, are imparted to the pulp. We give, herewith, the chief processes by which these changes are effected, and by which the substances above named are produced.

SCHMIDT'S PATENT OF 1867, NOW EXPIRED.

My improvement consists in the mode hereinafter described of treating paper, either in the process of manufacture or after it has been finished, and either in sized or unsized condition, whereby its strength and durability are greatly increased, it is rendered in a great degree, if not entirely, impervious to water, oil, and other fluids and gases, and also capable of resisting the destructive action of the strongest acids and alkalies.

My improvement is also applicable to the treatment of textile fabrics, such as linen and cotton cloth, rendering them in a great measure water-proof, and increasing their strength and durability.

By means of my improvement, vegetable textile fabrics, and especially paper, are rendered susceptible of application to many uses to which they are not adapted as ordinarily manufactured. This is peculiarly the case with paper, which is easily made from almost any description of vegetable fiber, and being readily moulded into any desired shape may, when rendered water-proof, air-proof, and acid-proof, by my process, be applied to a variety of useful purposes for domestic use, and in the arts and manufactures as a substitute for leather, glass, cotton and linen cloth, India-rubber, bladder, parchment, and various other articles, for many of which purposes it is vastly superior to the articles the use of which it is designed to supplant.

As applied to paper my process is as follows: The pulp being prepared of any desired vegetable fiber, in the ordinary manner, is made into paper by hand or by machinery, as usual, and before being made into sheets is exposed to a gentle heat, as is usual, to remove the excess of moisture and make it dry or nearly so. It is then passed through a bath consisting of a mixture of one part of glycerine ($C_6H_8O_6$) and two parts of oil of vitriol ($SO_3.HO$) and nine parts of water, mixed together and placed in a suitable vessel, which may, if desired, be conveniently attached to the paper-making machinery. The paper is immersed in, or passed through, this mixture until completely saturated therewith, when the excess of fluid is removed by pressure rollers or scrapers, or otherwise, the kind of apparatus used in my process being immaterial, so as it accomplishes the result.

The effect of this mixture on the fiber of the paper is to change its character and texture, and to form on its surface a gelatinous covering by the dissolving of portions of the pulp in the oil of vitriol, and the admixture therewith of the glycerine.

After the paper or pulp has been treated with this mixture of glycerine, acid, and water, it is passed through an alkaline bath, consisting of a solution of ammonia, soda-lye, or other alkali of sufficient strength to neutralize the acid of the oil of vitriol (the constituents of which are sulphuric acid and water), and arrest its further action on the fibers of the paper. The paper may then be passed through water, and afterward dried and treated in the usual way. If calendered by passing between heated rolls, care should be taken not to have the rolls too hot, which would render the paper hard and brittle.

Paper in sheets, either sized or unsized, may be treated in the manner described, after it has been manufactured and finished, in the usual manner, provided it has not been sized with animal gelatine or glue, and when treated by my process and dried, pressed, or calendered, possesses the qualities which I have described.

If paper-pulp in mass be treated in the manner described by my process, it may, while yet moist, after passing through the alkaline bath to neutralize the acid, be moulded into any required shape and of any desired thickness, to form vessels for holding water, acids, etc., or for soles of boots and shoes, for buttons, and for various other purposes. So, also, sheets of paper before being dried may be united at the edges to form bags or other articles, or may be laid in piles, one on top of another, and when compressed will unite in a solid mass or board of any desired thickness.

Cotton and linen cloth and other textile fabrics or articles of vegetable fiber may be treated, by my process, by passing them through the mixture of glycerine, oil of vitriol, and water, and afterward washed in an alkaline bath, and be thereby rendered stronger, more durable, and water-proof.

In describing the proportions of ingredients used for treating textile fabrics, paper, and other vegetable fibrous substances by my process, I have stated that which I find to accomplish the result successfully; but I do not wish to confine myself to the exact proportions which I have named.

It is almost impossible to enumerate the various purposes to which my invention is applicable. As paper prepared by my process is not injuriously affected by nitric acid or by sulphuric acid, cups or cells may be made of it for galvanic batteries, and vessels for preparing or manufacturing those acids, and other purposes in chemical operations and processes.

As paper so treated is very strong when wet, assuming the appearance of bladder, it may be used as an air-tight covering for cases and vessels, and for putting up chemicals, by being stretched over them when moistened; and as it resists the action of caustic alkalies, and is impervious to water or air, it may be used to advantage for inclosing such chemicals as deliquesce when exposed to the action of moisture or of the atmosphere.

Paper, when prepared in the manner described, assumes the appearance and has several of the characteristics of parchment, and is admirably adapted for use for legal and other documents requiring durability and permanency. When made thin, it is, also, owing to its great strength and toughness, even when wet with water, peculiarly suited for printing bank-notes, bonds, fractional currency, and similar purposes. It may, also, be used for water-proof lining for boots and shoes, for lining for tanks in oil and acid manufactories, for hat-bodies, for book-binding, for hose or pipes for oil, water, or steam, for valve-seats, for bags for carrying fluids, butter, ice-cream, etc., and for very many other purposes.

SCOFFERN'S PATENT OF 1869, NOW EXPIRED.

It is well known that ligneous matter, and more especially ligneous matter in the condition of paper and vegetable woven tissue, can be dissolved by immersion in copperized ammonia. It is well known, also, that if paper or vegetable woven tissue be immersed in copperized ammonia for a time insufficient to effect complete solution, whereby a pasty or glutinous condition of surface is obtained, and if two surfaces thus treated be brought together under pressure, they will adhere.

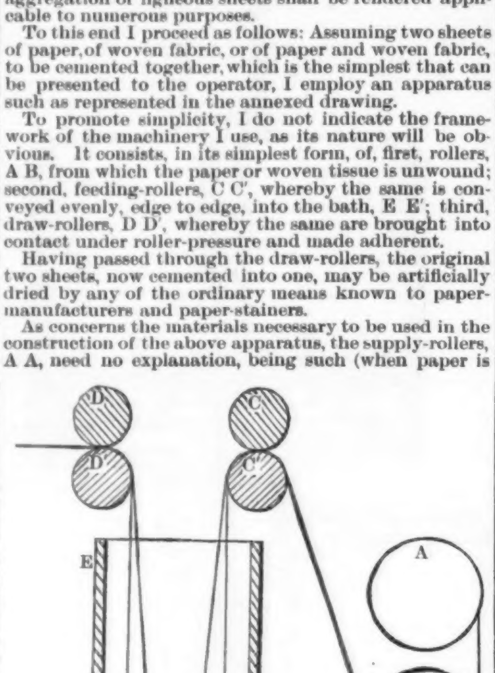
My process consists in so applying this principle that complete adhesion shall ensue, whereby the resulting aggregation of ligneous sheets shall be rendered applicable to numerous purposes.

To this end I proceed as follows: Assuming two sheets of paper, of woven fabric, or of paper and woven fabric, to be cemented together, which is the simplest that can be presented to the operator, I employ an apparatus such as represented in the annexed drawing.

To promote simplicity, I do not indicate the framework of the machinery I use, as its nature will be obvious. It consists, in its simplest form, of, first, rollers, A B, from which the paper or woven tissue is unwound; second, feeding-rollers, C C', whereby the same is conveyed evenly, edge to edge, into the bath, E E'; third, draw-rollers, D D', whereby the same are brought into contact under roller-pressure and made adherent.

Having passed through the draw-rollers, the original two sheets, now cemented into one, may be artificially dried by any of the ordinary means known to paper-manufacturers and paper-stainers.

As concerns the materials necessary to be used in the construction of the above apparatus, the supply-rollers, A A, need no explanation, being such (when paper is



used) as ordinarily come from the paper-manufacturer. The feed-rollers, C C', I prefer to be made of wood. The draw-rollers, D D', I prefer to be made of cast-iron, as being even better than steel, owing to the natural roughness of cast-iron, thus enabling it to gripe the bathed fabric, which, for some time after leaving the bath, is of the nature of a lubricant, more oily to the touch than even oil itself.

In order to have a full comprehension of my process, it is necessary to be aware that copperized ammonia develops an adhesive power altogether peculiar: First, not being in itself of the nature of gum, glue, or paste, it causes various matters with which it comes in contact to assume a gummy or pasty feel, whereby they become adhesive, and can be made to adhere; second, that unlike the case of glue, paste, or gum, the adhesive quality is not coexistent with mere wetness of surface, but rapidly passes away, so that in causing surfaces under my treatment to adhere, they must be brought into contact under pressure within the duration of a certain time after the two or more sheets under treatment have left the bath; third, it is necessary to bear in mind that copperized ammonia, if allowed to come into contact with vegetable matter for sufficient time, dissolves it wholly.

To render my process more clear, I will first assume my machinery put in motion, while the bath, E E', remains uncharged, whereby the two sheets of paper will be drawn dry. At the bottom of the bath three steel or iron rollers are sectionally represented. They are indicated in the drawing at r r' r'. The arrangement is such that one sheet of paper taking a turn round the topmost cylinder of the triangular group, while the other winds around the two lower rollers, it follows that the two sheets never come into contact while passing through the bath. The two sheets having passed beyond the draw-rollers, D D', they are dried and wound upon a roller. The subsequent drying and final winding-up arrangements have not, however, any novelty.

Now, I prefer (though it be not absolutely indispensable) to commence my operation, as already described, with an uncharged bath, seeing that, as hereinbefore explained, a too long immersion will cause solution of the paper wholly, not mere surface solution, which is alone desired.

As soon as the machinery has delivered the two dry sheets beyond the rollers, D D', and winding-up connection has been established, I charge my bath in the manner to be now described.

At the lowest side portion of the bath, a connection-pipe, p', is established between it and a reservoir of copperized ammonia. Turning on a tap, I cause the copperized ammonia to enter and rise upward to an extent shown by a glass gauge-pipe fitted to the bath, but not shown in the drawing. When the level has been attained that had previously been deemed necessary, that level must be preserved; otherwise the result will not be uniform.

It follows, from the nature of my operation, that the time of bath-immersion will vary according to circumstances, such as strength and condition of the copperized liquor, thickness or quality of the paper, depth of fluid in the bath, and, lastly, quickness or slowness of the machinery. As a general rule, I find that half a minute of immersion is sufficient; and whether the time of immersion be more or less, it may be regulated either by the depth of liquid in the bath or by the greater or less velocity of roller action, or both combined; or, lastly, by using copperized ammonia partially saturated, or "killed," by either ligneous or other matter already dissolved in it.

The manufacture of copperized ammonia I do not now claim; nevertheless, for the sake of precision, I state that the standard copperized ammonia preferred by me I make by immersing any quantity of copper, so long as it be in excess, in liquor of ammonia of 0·880 specific gravity, and permitting atmospheric air to enter from time to time.

Under favorable circumstances, a month's immersion suffices to perfect my product; but to satisfy myself of its perfection, I use the following test: I take a quarter of a yard, or about, of thin white Persian silk, to which (being thrust into a wide-mouthed pint bottle) I add half a pint of copperized ammonia and shake it. If the silk dissolve wholly in not more than a minute, I conclude the copperization of my ammonia to be sufficient. This is the best test of efficiency I know of. According to my experience, the test of specific gravity is not in this case to be relied on.

An essential matter has now to be taken heed of, and is this: My paper, in passing through the bath of copperized ammonia, takes cupreous matter out of the same, just as certain dye-stuffs are taken out of dye-vats; hence it may happen that the copperized ammonia deteriorates faster than the paper can take it up. To obviate this I establish two connections (not represented in the drawing) with the stock-tank, and a piston arrangement thereto, whereby a circulation of liquid is effected; or, what is more simple, when occasion favors, I have two tanks on different levels—one (the higher) to feed my bath, and the other to receive—thereby avoiding the need of piston or pumping circulatory arrangement.

Having described the manner of bringing two sheets of paper together, and incorporating them by my process, in the manner hereinbefore described, I must now state that three or more sheets may be similarly treated by an obvious arrangement and numeral increase of the bath-rollers, r, the object being to prevent contact of the several sheets until they come to the draw-rollers, D D'.

For some purposes, I modify the operation already described by passing single sheets through the bath and rollers, then subjecting them to reduplication, either each on itself (as in manufacturing a tube), or each upon a dry fabric, whereby I obtain a variety as to surface.

It must be particularly observed that neither sheets of paper nor of woven tissue can be practically cemented by copperized ammonia until the excess of solution withdrawn from the bath be cleared off, either by the pressure of rollers (which I consider best) or by a metal or glass straight-edge on a metal or glass plane, or two straight-edges.

It remains, finally, to state that the bath may be made of cast-iron, which is what I prefer. In no case must any part of the mechanism having to deal with copperized ammonia be made of brass in any of its varieties, or zinc. Copper, also, is interdicted, except when used with the specific intent of being dissolved.

SCOFFERN'S SECOND PATENT OF 1869, NOW EXPIRED.

My process consists in the application, to ships' bottoms and sides, and to other surfaces exposed to the action of sea-water, of certain materials, hereinafter to be specified, by way of sheathing, whereby corrosion, and other disintegration, may be prevented, lessened, or controlled.

It will conduce to the better understanding of my process, if pointed attention be called to the fact that each and all of the semi-fluid matters commonly used for the protection of ships' and other surfaces are popularly known as "paints." For present purposes I desire to limit the term "paint," as hereinbefore stated, to a semi-fluid holding a true oil as an integral component.

I will commence by describing what I will call a "preferential paint," by which is to be understood a paint that I consider answers better than any other for my subsequent operations, inasmuch as this paint holds copperized ammonia, or, rather, a product of the evaporation of copperized ammonia, as an integral part. The preparation of this copperized ammonia I will describe, notwithstanding that this body is already known, and its manufacture I do not, in this specification, claim to have been discovered by me.

Copperized ammonia, or (as some have denominated, though not, I believe, in accordance with chemistry), "copperate of ammonia," is the blue result occurring when liquor of ammonia has been brought into contact with copper surfaces, in the presence of atmospheric air, and allowed to remain in contact for a considerable time. By preference I use ammonia of 0·880, and any amount of copper, provided it be in excess of the ammonia's solvent power. The time of steeping or exposure varies with circumstances, but I consider six weeks to be an average time; whether more or less, is of no consequence, provided the result be efficient, and this may be known by testing.

The best test I know of depends upon appreciation of the remarkable fact that copperized ammonia, in good order, rapidly dissolves woody matter, and, still more rapidly, silk. Supposing, then, I desire to know whether a specimen of copperized ammonia be in good order for the preparation of either my preferential paint or certain semi-fluid sheathing-bodies, hereinafter to be described, and not coming within the category of paints, or the final laying on of paper or textile sheathing surfaces, I adopt the following test:

Having poured a convenient quantity of copperized ammonia (say half a pint) into a wide-mouthed stop-

per-bottle, of at least one pint capacity, I add thereto a test-quantity of one-quarter of a yard of thin white Persian silk. If, on agitation, the silk wholly and absolutely dissolves, within one minute, I conclude the copperized ammonia is adapted to all my purposes; if more than one minute be required, I conclude it not to be perfected, and that longer steeping of copper in contact with ammonia, with access of atmospheric air, is needed.

This is the best test of efficiency I know of. Specific gravity, for present purposes, I consider fallacious.

The fact is, however, that prolonged experience with copperized ammonia will place an intelligent operator beyond the need of using any test—appearances, not possible to describe, affording a sufficient guide.

Having described this copperate of ammonia, I will now explain its application, in the manner which I prefer, to the manufacture of my preferential paint.

The materials employed are linseed oil, India rubber, and copperized ammonia. To be precise, I will assume that one imperial gallon of linseed oil is to be operated on. Having turned this quantity of oil into a capacious boiler of iron or copper (it must not be of zinc), I add thereto one pound avoirdupois of India rubber, and boil until the latter is wholly dissolved. I then add one imperial pint of copperized ammonia, little by little. The commotion is very violent, and the addition must be made with care. I then boil until the last traces of ammonia, as indicated by the smell, have escaped. I then allow the whole to cool, and use it as a vehicle for holding any such body color as a painter may desire.

Having described the process of manufacturing this, my preferential paint, I will next describe the mode of preparing certain adhesive semi-fluid sheathing materials, necessary wholly or in part to my process. These said adhesive semi-fluid sheathing materials I do not call paints, nor the operation of laying them on painting, inasmuch as no oil proper, or fatty acid, in union with glycerine, enters into their composition.

For the sake of precision, I will individualize those hitherto used in my sheathing process, by the numbers from 1 to 8.

No. 1. Marine glue and liquor of ammonia, of 0·880 specific gravity, of each equal weights, to be digested in contact with copper, in a closed vessel, to which atmospheric air may be admitted from time to time, agitating occasionally until solution be complete. The result will have the consistence of thick black paint. It is to be observed that I use marine glue in this case for convenience. The materials of marine glue will answer equally well. It is to be further observed that instead of letting the preparation of copperized ammonia go on simultaneously with its further solvent power on marine glue, copperized ammonia, already prepared, may be employed, and to the saving of some time; but whether ammonia or already made copperized ammonia, surfaces of metallic copper should always be superadded.

No. 2. The same mingled with white arsenic. The proportions I find to answer best are six parts, by weight, of the aforesaid black adhesive matter and one part, by weight, of white arsenic.

No. 3. The same as No. 1, pitch being substituted for marine glue.

No. 4. The preceding, arsenicalized.

No. 5. The same as No. 1, resin being substituted for marine glue.

No. 6. The preceding, arsenicalized.

No. 7. Two parts, by weight, of lead soap (ordinary lead plaster) and one part ammonia of preceding strength, the whole treated exactly as No. 1.

No. 8 is the same arsenicalized.

Having described the preparation of my preferential paint, and the adhesive sheathing matters, not to be called paints (inasmuch as they do not contain oil proper), I will now go on to explain their use in my process of marine sheathing.

First, as regards iron ships, the circumstances are such that processes for protecting iron bottoms have to be performed under many varying conditions.

The ship may be quite new, and the time at the operator's disposal practically unlimited. The ship may be old and worn; may have been subjected to painting or smearing, by compounds unfavorable to my treatment; may be laid up in a graving-dock for the smallest available time, whereby the sheathing or painting operator is hurried.

Again, the duration and direction of a voyage will have to be consulted. A ship destined for Calcutta will need less protection, for example, than one destined for Bombay.

Assuming an iron ship to be perfectly new, I first lay on two coats of my preferential paint, or rather paint-vehicle, mingled with any convenient body-color. I prefer red lead.

A prejudice lies against this material, because of a prejudicial chemical action sometimes set up. There can be no chemical action, however, so long as the paint is dry, and my subsequent processes of sheathing keep it dry.

As soon as the second coat of paint has firmly set, I lay upon it sheets of paper, linen, or calico, either of which has been steeped in copperized ammonia, in good condition, for about one minute, a time sufficient to have promoted surface solution of the materials steeped, and to bring about adhesion, when the applied sheet has been rubbed down by a pad of linen, calico, or caoutchouc.

This vegetable sheathing will dry hard and adhere firmly.

Upon convex and plane surfaces it always sticks tightly. From concave surfaces it may separate by the shrinkage of drying, if not slit at intervals, more or less frequent, according to the abruptness of the concavity; but what I prefer is, to treat concave surfaces by a special modification of my process, which is the following:

Upon the painted surface, I smear one coat of either of my adhesive sheathing semi-liquids, by preference No. 2, and allow to dry. When dry, I smear another layer of the same, and to this, while wet and ammoniacal smelling, I apply, by pressure and rubbing, sheets of paper, calico, or linen that have already been steeped, for about a minute, in copperized ammonia, withdrawn, and allowed to dry. They will adhere perfectly.

Sheets of paper or woven vegetable material will desquamate under the action of sea water, just as copper desquamates.

For the majority of voyages, they need no reduplication or covering. I usually recommend, however, a finish of one of the sheathing semi-liquids, numbered from 1 to 8.

A brush, not of bristles, but of vegetable fiber, is best adapted for laying on these sheathing-glazes.

I have here to repeat that my preferential paint, though best adapted to my sheathing-process, is not indispensable. Any ordinary paint I can operate upon, provided it really be paint, that is to say, a compound made up of body-color and a true drying vehicle, such as a real oil, with or without turpentine.

Many, I may state most, of the so-called marine paints are chemically regarded, and, according to the scientific chemical limitation, no paints at all; they are merely greasy, permanently moist smears.

Upon surfaces such as these, I cannot lay either my sheathing, semi-fluid, adhesive bodies or my sheet-sheathing successfully.

Upon a dry coating of any ordinary paint I can operate as follows:

Although sheets of paper or woven vegetable material that have been immersed in copperized ammonia for the time specified, and withdrawn, will not stick with any practical efficiency to ordinary paint, they will stick with efficiency to a surface of any one of my sheathing, adhesive semi-liquids, laid on dry ordinary paint. Herein lies the solution of the problem.

It remains to be observed that either of my sheathing, adhesive semi-liquids, from 1 to 8, may be laid on an iron surface directly, if such surface be neither acid nor greasy, understanding by grease, fatty or oily matter, not having the quality of drying.

Although I have hitherto treated only of the application of my process to iron ships, yet it is applicable to wooden ships. It is also applicable to the covering of other surfaces; for example, iron, copper, or yellow metal, of iron bridge work. In short, the portion of my sheathing process which has reference to the laying on of either of my sheathing, adhesive fluids can be applied to any surface, however irregular, and even the portion which relates to the laying on of paper or woven sheets can be applied to surfaces having considerable irregularity of outline.

I would observe that the fullest development of my sheathing process is made up of the following stages:

First. Painting either by my preferential paint or else some true paint, as already defined.

Second. The laying on of one or more of my copperized ammonia sheathing semi-fluids, if the paint used has not been my preferential paint.

Third. The laying on of paper or woven tissue sheets by one of the two processes already described.

Fourth. The sheathing not to be confounded with painting with one of my specified sheathing, copperized semi-fluids.

Nevertheless, the operation may be stopped at any stage, according to the amount of protection desired.

SCHMIDT'S PATENT OF 1871.

My invention relates to the treatment of paper, paper-pulp, and other vegetable fibrous substances, whereby they are greatly increased in toughness and strength, rendered impervious to water, capable of resisting the action of most acids and alkalies, and made either firm and hard or soft and pliable, as may be desired.

My improved process may be applied to paper, sized or unsized, and made of any vegetable fiber, or to other vegetable textile fabrics, or to paper-pulp, which after treatment may be made into sheets of paper in the ordinary way, or moulded into any desired shape.

The first step in the process is to immerse the paper-pulp, or other substance to be treated, until it is saturated, in a bath of concentrated mother-water or liquor resulting from the manufacture of chloride of zinc, or of the chlorides of tin, calcium, magnesium, or aluminum. As this mother-water is a waste product, and not commonly an article of merchandise, and therefore not easily obtained in sufficient quantities, it will be more convenient, as well as more economical, to produce it for this express purpose from the manufacture of the chlorides above named, which are easily made and command ready sale. For this purpose (if chloride of zinc is employed) I dissolve metallic zinc in dilute muriatic acid, and then concentrate the solution by heat to about 70° or 75° Baume. On cooling, the solution will deposit crystals of chloride of zinc, which being removed, the resulting mother liquor is obtained. To this mother liquor I then add a solution of chlorine in water until the presence of chlorine is detected by the smell on the agitation of the liquor. This solution may be obtained by dissolving chloride of lime in water to the strength of from 1° to 2° Baume. I then add to the liquor a sufficient quantity of carbonate of zinc (or any other carbonate) to render the solution neutral.

If it is desired to render the paper or other substance to be treated very opaque, I add to the bath of mother liquor as much oxide of tin or oxide of zinc (or other suitable oxide) as it will retain in solution. For this purpose an excess of oxide is preferable, so as to insure the desired effect. Care should be taken not to employ ingredients having iron or sulphur in combination when it is important that the color of the article to be treated should not be injured.

The paper or other fabric to be treated should be heated before being immersed, so as to expel all moisture and facilitate the process. This may be done by passing it through a heated chamber or over a heated surface, the plan which I find most effective being to pass it over a hollow metallic roller heated internally by steam or otherwise, with a surrounding jacket having slits for the paper or fabric to pass through between the roller and the jacket.

The heating chamber, roller, or other apparatus should be so placed that the paper, etc., may pass immediately from it into the bath of mother-liquor, so as to lose as little heat as possible.

The vessel containing the chemical bath should be made of lead, sandstone, or other substance not readily affected by chlorine, and should be sufficiently large to permit the paper or other fabric, if in a continuous sheet, to pass backward and forward within it while immersed in the bath. This may be effected by the use of a series of leaden rollers, over which the paper, etc., may pass up and down, or horizontally, so as to remain a sufficient time in the bath to become completely saturated; or a series of baths may be employed, if preferred, for this purpose.

As the paper or other fabric passes out of the chemical bath the surplus adhering liquor is removed by means of scrapers, or by passing between rollers, and is allowed to run back into the bath. The paper or other fabric is then passed into a trough of water and washed until free from all surplus liquor. This water may be made slightly alkaline by the admixture of carbonate of soda or other alkali, so as to neutralize any adhering liquor. The paper or other fabric thus treated is then dried slowly at moderate heat, and afterward smoothed and calendered, if desired, in the manner usual in the manufacture of paper.

By this process the paper or other fabric is rendered strong and tough, approaching, in these respects, to the quality of parchment or skin, while some degree of flexibility is retained.

Paper thus treated may be made of any desired thickness by placing together the sheets as they pass from the chemical bath, as by rolling continuously around a cylinder, or otherwise, and uniting them by pressure, after which the article thus formed is washed in water to remove the surplus liquor. The requisite pressure may be obtained by using a pair of rolls, one of which should be heated.

Paper-pulp or other vegetable fiber may be saturated in the chemical bath, and then moulded by pressure into any desired form, and then hardened, as hereinafter described.

To make from paper, paper-pulp, or other vegetable fibrous substance an alkali having the solidity and hardness of horn or vulcanite, I employ the same chemical bath as before described, but concentrated to a strength of about 50° Baume, or upward, according to the article to be treated. The bath is heated to about 150° Fahrenheit, and the paper or other article, after being first heated and then saturated in the bath, as above described, is passed (on leaving the bath) over or between heated rolls, and then plunged in water, pure or only slightly alkaline, in which it is allowed to remain for from six to twenty-four hours, according to degree of hardness required, after which it is subjected to pressure to solidify it and make it smooth or give it any desired shape. It is then slowly dried at a temperature of from 70° to 80° Fahrenheit. It may be made of any required thickness by bringing together several plies or layers as it passes out of the chemical bath. A still greater degree of hardness may be attained by dissolving in the chemical bath vegetable fiber, dextrine, gum, or starch, and also by sifting on to or between the layers of the paper or fabric, as it passes from the bath, any mineral substance or gum.

A rough texture or surface may be given by sifting emery, powdered glass, sand, or other mineral substance between the layers or on the outer surface, as may be desired, and paper or other vegetable fiber thus prepared may be used for many purposes in the arts. If, on the other hand, it is desired to produce a substance having great flexibility and softness, resembling soft vulcanized rubber without the elasticity of that article, the paper or other fabric is immersed to saturation in the chemical bath in the manner first above described, and then, as it leaves the bath, it is passed over a heated roller of lead (or other suitable material) into a washing vessel containing a weak solution of any suitable alkali in water, and thence into a bath of a solution of water and glycerine in the proportions of two parts by measure, of water, to one of glycerine, or a solution of sugar and water in similar proportion. This glycerine or sugar bath may be used cold, but it is better to have it heated a little below 212° Fahrenheit. In this bath it should remain about six hours, or more, according to the degree of softness required.

Paper thus prepared, and made of suitable thickness by uniting several plies as they pass from the chemical bath, makes excellent belting, the strength of which may be increased by introducing, between the layers of paper, cloth made of cotton or vegetable fiber, either dry or previously saturated in the chemical bath, as may be preferred; but it adheres better if inserted dry.

In uniting several thicknesses of paper or other vegetable fabric as they pass out of the chemical bath, a pair of rolls may be used, so arranged as to give the requisite pressure, and yet allowing a gradual separation as the thickness of the article passing between them increases, the upper roll being heated to from 120° to 200° Fahrenheit, and the lower one, around which the paper, etc., is to pass, being partially immersed in the bath of alkaline solution, or of glycerine and water, or sugar and water, as the case may be.

The paper, paper-pulp, or other fibrous vegetable substance treated as above described, when of suitable thickness is extremely soft and pliable, and resembles soft leather in texture, and may be used for many purposes for which leather is employed. When of increased thickness it may be employed for belting, packing, and various other purposes to which soft vulcanized rubber, owing to its great elasticity and its liability to be acted upon by heat and various chemical substances, is inapplicable. When manufactured in a hard state, by omitting the glycerine or sugar treatment, it may be made as horn and used for various purposes, being susceptible of being moulded or otherwise formed into any desired shape.

The article thus produced, whether soft or hard, when exposed to sufficient heat burns without flame, and is not readily combustible. It may be used to advantage in making hose or pipe for conducting water, gas, and other fluids, and also for the bodies of carriages, railroad cars, or boats, and for various other purposes in the arts and manufactures.

The details of machinery and apparatus employed may be varied to suit the convenience of the manufacturer and the character of the article to be made.

I do not claim the use of a solution of chloride of zinc or chloride of tin for the purpose of treating paper and other vegetable fibrous substances; but, as distinguished therefrom:

I claim as my invention—

1. The treatment of paper (sized or unsized), paper-pulp, and other vegetable fabrics and substances, with a bath of the mother-water of the chlorides of zinc, tin, calcium, magnesium, or aluminum, or other of them, with or without the admixture of carbonates and oxides or other substances, and the subsequent washing with water or alkaline solution, substantially as and for the purposes described.

2. The treatment of paper, paper-pulp, or other vegetable fabrics and substances (which have been previously saturated with or immersed in a concentrat-

ed solution of chloride of zinc, or other chlorides hereinbefore specified, or of the mother liquor of such chlorides or their equivalents) with a solution of glycerine and water, or sugar and water, substantially as and for the purposes described.

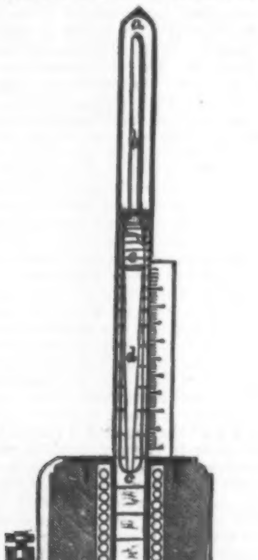
3. The combination of a layer or layers of paper, treated in the manner hereinbefore described, with a layer or layers of vegetable cloth similarly treated, for the production of a new manufacture suitable for belting, packing, and other purposes, substantially as described.

4. The combination of paper, paper-pulp, or other vegetable fibrous substances, treated, substantially as hereinbefore described, with emery, powdered glass, sand, or other pulverized or granular metal or mineral, as a new article of manufacture.

(To be continued.)

NEW AEROMETER.

THE idea of balancing the attraction which a solenoid exerts on a piece of soft iron against the resistance which a fluid exerts to the lowering of a floating body has been repeatedly employed to measure currents and potentials. Karl Raab has had different arrangements of this fundamental idea patented. The figure shows one of these arrangements. In the hollow of a solenoid there is fastened a glass tube, closed at both ends, which is filled with alcohol or some other mobile liquid. On the liquid floats the glass aerometer, *b*, *c*, which contains in its under part a thin conical iron tube, *d*. When a current passes through the solenoid, the attraction of the iron core causes the aerometer to sink more or less, according to the strength of the current. The scale is divided empirically. The magnetic force keeps the aerometer always in the center of the glass tube, so that it does not adhere to the sides. The wording of the patent would include a somewhat similar contrivance designed by Lalande.



It is believed that this kind of instrument may be very useful with a fitting choice of the form and quality of the iron core; but the heating of the coil by the passage of the current may make corrections necessary on account of the alteration of the density of the fluid and of the volume of the different parts of the instrument, and it will be necessary for great accuracy to place a thermometer in it. To make the heating of the coil have as little effect as possible, it would be advisable to separate it by a layer of air from the glass tube.—*Elektrotechnische Zeitschrift.*

NOTES ON MAIZE OIL.

By E. B. SHUTTLEWORTH.

A NEW process for the removal of the integument and embryo of Indian corn has recently been made the subject of a patent in the United States. It has already been successfully applied to the preparation of grain for conversion into glucose, and is now being turned to good account in the manufacture of starch. It also seems likely that the process may be used to advantage by the distiller, as it is probable that some of the leading impurities in corn spirit originate in those parts of the grain which the process is designed to remove.

The Toronto Sirup Company have acquired the right to use this patent in Canada, and have now just completed the erection of the machinery and plant necessary to operate on seven hundred bushels of corn per day. Having been engaged in an examination of the rejected portion of the grain, more especially the germ, I have taken the liberty of presenting a few facts which will probably be new to most persons.

By the process of grinding, which constitutes the peculiarity of the patent, the albumen or starchy portion of the grain is thoroughly disintegrated, while the pericarp or hull, with the embryo, are completely separated. The weight of the two latter obtained from a bushel of corn of 56 lb. is 16 lb., from which from 8 or 9 lb. of germ may be obtained by sifting. These portions are, at present, sold for cattle food, and can be readily disposed of at 1 cent per pound, but it is more than likely that under proper manipulations they can be made to furnish products of considerable economic value.

The germ is obtained in the form of a flattened white horn-like substance, and is with difficulty pulverizable. On being subjected to pressure it yields a quantity of fixed oil, and a similar product can be obtained by the use of appropriate solvents.

The oil has for some time been known to chemists, but as far as I have been able to ascertain, has not been made the subject of investigation. It is of a pale yellow color, which quickly becomes greenish by contact with copper. Its consistence or viscosity is greater than that of olive oil, and is similar to that of almond oil. The taste is at first bland, but is followed by some acridity, and the odor is sourish, recalling the smell of a baker's work-shop or distillery. The specific gravity of the oil obtained by pressure is 0·92.

It is readily soluble in ether, chloroform, carbon disulphide, and oil of turpentine; mixes less readily with petroleum ether and fusel oil, and is sparingly dissolved by cold alcohol, but is more soluble in boiling alcohol, from which it separates on cooling.

Sulphuric acid of specific gravity 1·843 produces a blackish-brown coloration; nitric acid, specific gravity 1·420, destroys the yellow color and produces a very slight tinge of red; sirupy phosphoric acid is without effect, as is also hydrochloric acid containing sugar.

The elaidin test with mercury and nitric acid produces in thirty minutes a yellowish-orange color, followed by partial solidification, showing the oil to be of the non-drying class.

The amount of oil contained in the germ, as estimated by ether, by cold prolonged extraction is 11·75 per cent. I have not yet had time to arrange for a more thorough trial with boiling ether, but do not think this quantity will show much increase by this method, as the powder used was fine and the percolation thorough. The statement now going the rounds of the papers that a company in St. Louis obtains from a bushel of corn 1 gallon of oil, worth 75 cents, is, of course, utter nonsense, as the entire weight of the germ from that quantity would only be slightly over the weight of a wine gallon of oil (7·66 lb.).

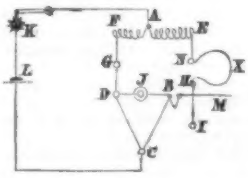
As to the commercial value of the oil, it is at present difficult to say. In its crude state it would not command a high price on account of the objectionable odor, but this might, doubtless, be removed by proper treatment so as to bring the product up to the grade of refined cotton-seed oil.

The germ yields to cold alcohol a small quantity of oily matter, containing a volatile odorous principle of a very decided and penetrating grain-like smell, strongly resembling that of crude spirit. The separation of the germ from the corn, prior to the mashing process, would probably enable the distiller to secure a purer ethylic alcohol than at present possible, and I believe the experiment to be one well worth making. The corn does not contain any alkaloidal body which responds to the ordinary reagents.—*Canadian Journal.*

SELF-INDUCTION.

WHEN Professor Hughes, President of the Society of Telegraphic Engineers and Electricians, delivered his recent inaugural address to that body on his recent experiments on the self-induction of an electric current in wires of different form and material, the method he had adopted in making his observations was questioned by some able critics, and he has since gone over the same ground with a modified testing apparatus designed to be free from the objections which were made against the earlier instrument. The more recent observations have just been communicated by Professor Hughes to the Royal Society, and in the present article we shall endeavor to give an account of these, which will be found to bear out the important results formerly arrived at.

The new device adopted by Professor Hughes in his investigations is sketched in the figure, where A, B, C,



and D are the four sides or resistances of the modified "induction bridge," the telephone, J, replacing the galvanometer used in the ordinary Wheatstone bridge. The sides, C B and C D, are formed of German silver wires, each being 50 centimeters in length, 0·5 millimeter in diameter, and having 0·85 ohm resistance. The sides, A B and A D, have also 0·85 ohm resistance, so that the four sides have equal resistance, and thus remain constant during the experiments.

The spirals, A E and A F, are of hard copper wire, silk-covered, of 1 millimeter diameter and 4·80 meters in length, wound loosely on a boxwood cylinder of 3·50 centimeters diameter and 30 centimeters in length. The spires move freely upon this core. There are forty spires, each of 4 centimeters diameter, and these are separated from each other by a space of 5 centimeters. The middle of the two spirals is fixed to a collar of wood, by means of which the spiral on either side can be pressed closer, so as to alter the induction of the spires on each other. At E and F there are also adjustable collars of wood, and as the boxwood cylinder is graduated, the degree of approximation of the spires may be read off. The mutual induction of the spires can thus be brought to balance on each side.

In practice, Professor Hughes prefers to move the central collar, raising the end collars only for the perfect adjustment of the zero. This action gives a double effect by closing one coil, say that from A to F, and thereby increasing its "mutual" induction, while at the same time opening the other coil, namely, that from A to E, and diminishing its mutual induction. The end, F, of the helix is joined to about 10 centimeters of German silver wire, completing the circuit from G to D. This supplementary German silver wire is simply for the purpose of making the resistance of A D equal to D C, and its length should be adjusted to this purpose. The end of the helix, E, joins directly with the terminal, N; the wire to be tested, X, is joined to N and H; and from H to I there is a second supplementary German silver wire, allowing us, by means of the contact side, M, which is in direct communication with B, to introduce more or less of the German silver wire in the side, A B. The resistance of the wire to be tested should always be less than that of the opposite side of the bridge, and we then make up the total resistance of A B by sliding the contact slide, M, until the resistance of A B equals A D.

From the construction of this apparatus it will be seen that there can be no change in the resistance of either side of the bridge when the zero is found. The resistance from H to M can, however, be kept constant when desired, and the resistance or length of the German silver wire, G D, may be varied. The wire, X, is then balanced by an equal resistance on the opposite side of the bridge. In the latter case, however, the battery and telephone circuits no longer possess the invariable relations which are so necessary in experiments of the kind in question.

The battery circuit is connected up in the usual manner to A C, and the current is interrupted by a rheotome, K; or by a commutator the battery circuit can be closed, and the interrupter transferred to the bridge or telephone wire, B D. In this way the effect of an intermittent current on the wires can be observed, as compared with the effect of a steady current. In other words, the results of the "stable period" and the "variable period" can be observed.

In the rheotome a contact spring rests lightly on a wheel whose roughened surface is divided into eight equal parts of contact and insulation, by means of which the telephone gives out eight equal periods of sound and silence at each revolution of the wheel. In this way the ear can appreciate feeble sounds better than if there were no periods of silence; and as the wheel can be made to revolve at any rate between two and ten revolutions per second, there are from sixty to eighty periods of silence between each rubbing contact per second.

The apparatus has been made by Mr. W. Groves, of Bolsover Street, with great care. To calibrate it, Professor Hughes introduces as the wire, X, successive 10 centimeter lengths of copper wire one millimeter in diameter, thus forming a table of values throughout the range of the induction balance, running up to a total length of 20 meters by increments of 10 centimeters. The unit of self-induction adopted by Professor Hughes is that given by a straight copper wire one millimeter in diameter and one meter long. This gives on the calibrated scale 100°, and with this standard all the comparative forces of the extra currents observed have been compared.

The self-induction of a wire is proportional to its length, consequently a source of error might exist in the different lengths of the supplementary resistance wire, H I, introduced to balance the resistance of G D; but as the high specific resistance of German silver wire allows of a great change in resistance by a small movement of the sliding scale, this error is in most of the comparative experiments but a fraction of one per cent., and when taken into account, as it should be, the error no longer exists.

The telephone used should be of the most perfect kind, and expressly adjusted for rapid and feeble sounds. Professor Hughes has found it best to employ an extremely soft Swedish iron diaphragm, without varnish or anything that can deaden or diminish the sound. Its fundamental note should be higher than those generally in use, or at least 500 double vibrations per second. In practice the wire, X, is attached to two frames of wood, articulated together at D. By this means the terminals, N H, can be separated, and straight wires, sheets, or tubes of metal introduced, varying in length from five centimeters to one meter.

The primary object of the researches of Professor Hughes with this apparatus being to observe the self-induction which takes place in straight wires or wide loops, where the reaction from any return wire is not appreciable, he has adopted the term "self-induction" to indicate effects due to the current in its own portion of wire, and the term "mutual induction" to indicate the effects of the reactions of different portions of the current and circuit on each other, as in the case of coils. His experiments show that these two effects are distinct from each other, for copper wires have a low coefficient of self-induction and a high coefficient of mutual induction, whereas in iron wires these properties are reversed.

The former researches of Professor Hughes showed a marked difference in the self-induction of copper and iron wires, and this difference is verified in the recent experiments; the fall of electromotive force of self-induction due to increase of diameter of the wire being still more rapid than as shown by the old method. For example, with iron and copper wires of the diameters given, the comparative electromotive force was as follows:

	mm 0·25	mm 0·50	mm 1·00	mm 2·00	mm 3·00	mm 4·00	mm 5·00	mm 6·00	mm 7·00	mm 8·00	mm 9·00	mm 10·00
Iron..............	760	621	530	360	269	230	190	171	152	138	128	124
Copper	129	113	100	89	82	78	75	73	72	71·5	71·2	71

It will be seen from the above table that self-induction in iron is peculiarly sensitive to a change in the diameter of the wire, having nearly six times the electromotive force of copper in wires of 0·25 millimeter in diameter, and not twice the electromotive force of copper in wires of 10 millimeters diameter.

The decrease of the electromotive force of self-induction by increase of diameter should, according to Professor Hughes, be considered as an effect due to a number of independent streamlets of current acting on each other, rather than one whole current in the wire. The fact of the great reduction of the electromotive force in flat sheets is an argument in favor of this view. A still more striking argument is the fact that when the strip is subdivided up into longitudinal strips, or into wires placed parallel, the self-induction is still further reduced; the streamlets being as it were separated more completely from each other. When iron is in the form of a thin flat strip, it behaves like copper-brass and the non-magnetic metals as far as self-induction is concerned, a fact which Professor Hughes thinks is due to the disappearance of its circular magnetism when in that form.

With regard to the mutual induction of iron and copper, that is to say, the induction in a wire due to the reactions between the separate portions of the wire on each other, Professor Hughes finds that a copper wire closely doubled on itself, or wound in ten layers of a coil, has a very high mutual induction, whereas an iron wire in the same form has a very low mutual induction. The relative figures given are 507 per cent. increase of induction for copper, and only 13·6 per cent.

increase for iron. This remarkable difference is also believed to be due to circular magnetism in the iron, for when ribbons of iron are substituted for the wires, the coefficient of mutual induction is the same as that for copper, and the iron no longer behaves as a magnetic body. A stranded iron wire, with its circular magnetism broken up in this way, also behaves like copper. A wire of iron heated to a yellow-red heat loses its high inductive capacity and behaves like copper, owing probably to the loss of its circular magnetism by the heating. Moreover, an iron strip, having little or no circular magnetism when cold, shows no appreciable change of inductive capacity when heated to a yellow-red.

In reference to the higher resistance of a wire during the "variable period," that is to say, while the current is rising in it to its full strength, Professor Hughes had made a great variety of experiments, which led him to the remarkable conclusion that from the time when the current first begins to enter the wire (previous to which the resistance may be regarded as infinite) there is a rapid fall of resistance as the current gains strength, until the normal resistance is reached, when the current is in its "stable period." This fall of resistance from infinity downward can be represented by a curve; and although the telephone cannot give the form of this curve directly, it gives by the nil-method comparative results as to the different durations in time of the curve for different metals. This change of resistance is a real *bona fide* change in ohms.

Another curious result of these experiments is that a change in the resistance of the wire tested in the bridge causes a momentary current to pass through the telephone in the same direction as the extra current, and if these were not separated by balancing the extra current by the induction balance, the mixed effect would be read as a single effect of the extra current. This momentary "primary current," as Professor Hughes calls it, which is due to the extra resistance, greatly exceeds that of the extra current. Consequently all measurements taken wherein this separation is not complete gives the result of a mixed effect.

The following table gives the resistance of iron and copper in the stable and variable periods:

Wires 1 meter in Length and 5 millimeters in Diameter.	Comparative Force of the Extra Current.	Resistance in Ohms in the Stable Period.	Resistance in Ohms in the Variable Period.	Percentage of Increased Resistance in the Variable Period.
Copper....	78	0·001284	0·001372	7
Soft Swedish iron............	234	0·008346	0·022200	186
American compound wire, copper exterior, steel interior...........	83	0·002247	0·002696	20
Ditto, steel exterior, copper interior....	213	0·007750	0·024800	220

The table shows that copper and the American compound wire coated with copper has an extremely rapid action or curve from an infinite to its stable resistance, due to its freedom from circular magnetism, while iron shows a comparatively slow curve. A remarkable result will be seen where a copper wire has been coated with iron, its variable resistance being 220 per cent. above that of its stable period and 54 per cent. greater than that of a solid iron wire.

The effect of more or less rapid periodic contacts on the resistance of the variable period as given by the telephone and induction bridge has also been investigated to some extent by Professor Hughes, who found that the telephone he used responded to the vibrations of its own dominant note, each diaphragm selecting its own period from the confused periods of contacts made by the scraping contact maker of the rheotome.

From these experiments, which are not yet fully published, we may extract the following fact, namely, that an intermittent current of six contacts per second in an iron wire of 6 millimeters diameter shows an increase of 14 per cent. resistance in the variable as compared with the stable period. An ordinary Morse telegraph instrument, working at the slow speed of eleven words per minute, would experience this additional resistance in the wire. The effect could, in the opinion of Professor Hughes, be shown by the galvanometer if the extra current could be separated from that due to increased resistance.

The iron wire of 6 millimeters diameter shows for a speed of 384 contacts per second a comparative resistance in the variable period of 638, or more than six times its stable resistance; but with 192 contacts per second its resistance is but 371. The fall of resistance is so rapid here that for a single octave difference in the note of the telephone it is far greater than the whole stable resistance. The extra current, as is well known, is proportional to the length of contact for fine wires, but in large wires the curve indicates that the extra currents have a local reaction on the cessation of the primary current.

An external tube of iron insulated from its central core is the form of conductor which gives the maximum increased resistance during the variable period. In the case of a copper wire insulated in the interior of an iron gas tube, the percentage increase of resistance in the variable period was 600. In the case of a bar of unsheathed copper wire, the percentage increase was only 7. The force of the extra currents is also greatly increased by the iron tube outside, iron showing the highest percentage of increase, namely, 615, while insulated copper showed 410 per cent. The percentage increase of resistance in the variable period for iron wire was only 188, as compared with the 600 per cent. for insulated copper when the iron sheath was used.

Professor Hughes sums up the observations made in the following sentence: "The percentage of increased resistance of a metal when under the influence of an insulated magnetic sheath is directly as its conductivity or inversely as its specific resistance."

The reaction of the iron tube is electro-magnetic, and as the atmosphere is also magnetic its reaction may be similar, though in a less degree to those mentioned. The question of the sheathing of submarine cables by iron wires having been broached after the earlier experiments of Professor Hughes, he has investigated the matter with specimens of cable, but finds that the stranding of the wires in spiral layers reduces the effect to a mere fraction of what it would be with a solid iron sheath or case. The galvanizing of the wire, and perhaps also the coating of hemp, helps to diminish the effect. Nevertheless, the experiments show that when in tunnels insulated wires are run in iron tubes, the effect must be considerable.

Several well known effects of induction in coils with iron cores have also been investigated by Professor Hughes. He finds not only that the force of the extra currents is, as is well known, increased by substituting a bundle of fine wires for a solid core, but the resistance of the variable period falls considerably. The experiment proves, according to Professor Hughes, that the extra resistance in these coils is due both to the electro-magnetic inertia of the eddy currents, and the inertia of the magnetic molecules of iron.

These results of Professor Hughes are of great theoretical and practical value. Already they have been to some extent applied in practice, and they have also borne fruit in the minds of mathematicians. Possibly, they may bring us a step nearer to the solution of the great problem, What is an electric current? Before leaving the subject for the present, we shall briefly sum up the results of the experiments so far as they have gone. Professor Hughes has shown us: 1. That contiguous portions of the same electric current react upon each other in the interior of a conductor just as portions of the current or circuit react externally on other portions of the same current or circuit. 2. That the coefficient of mutual induction is less in iron than in copper wires, but about the same for both when the metals are in the form of a thin ribbon or strip. 3. That the inductive capacity of a conductor of magnetic metal depends on the formation of circular magnetism and not on its internal magnetic permeability. 4. That a magnetic metal can be rendered as free from circular magnetism as a non-magnetic metal. 5. That we have experimental evidence of electro-magnetic inertia and the deleterious effects of eddy currents in the cores of electro-magnets. 6. The discovery of a large increase in the true or ohmic resistance of conductors during the variable period when the electric current is growing in them, allowing of the gradual rise of the current being measured.—*Engineering.*

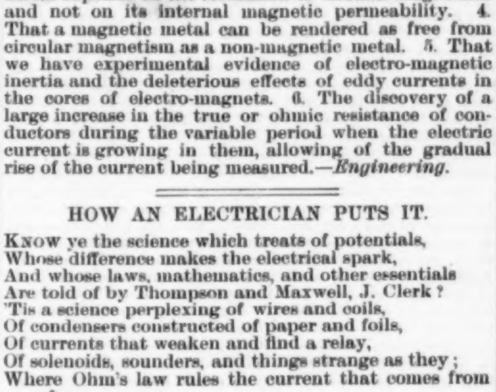
HOW AN ELECTRICIAN PUTS IT.

KNOW ye the science which treats of potentials,
Whose difference makes the electrical spark,
And whose laws, mathematics, and other essentials
Are told of by Thompson and Maxwell, J. Clerk?
'Tis a science perplexing of wires and coils,
Of condensers constructed of paper and foils,
Of currents that weaken and find a relay,
Of solenoids, sounders, and things strange as they;
Where Ohm's law rules the current that comes from afar,
Namely, C = E divided by R;
Where specific inductive capacity still
Farads micro- or mega- can easily fill.
You remember the units they call C. G. S.
The dyne and the erg, and the rest, more or less;
Ohms, volts, the sweet units entitled B. A.,
Siemens', Varley's, etc., a stately array.
Now just as the volts, E. M. F. which denote,
Multiplied by amperes in the usual rote,
Give a unit called weber, so you, love, and I,
You potential, I strength, should in harmony vie;
We should weave a soft web(er) of destiny twain,
And another new unit forever remain.

A MAGNETO GENERATOR KEY.

By SAMUEL VYLE.

AFTER many trials to generate currents by some mechanical means, the author discovered that if a pair of Bell telephones be connected up as a closed circuit, and the ferrotype plate be removed from one of them,



and the flat edge of this thin plate be tapped upon the magnetic core, within the wire coil, those taps generate currents which are distinctly reproduced in the second or receiving telephone. With a piece of soft iron of greater mass the signals are louder, but both dots and dashes come out clear, and are as easily read as when a voltaic current is used. With a Gower-Bell magnet and its tiny coils, when tapped with a soft iron key, signals have been read through 30,000 ohms resistance.

The accompanying key is its own generator, and is submitted for view and trial as admirably adapted for military purposes where the telephone is used as a receiver. Its construction is very simple, being composed of a small horseshoe-shaped permanent magnet, each pole being fitted with a soft iron core, wound with wire to about 50 ohms each, and joined up in series. The handle, or keying part proper, is of soft iron, and when depressed against a spring is brought into direct touch or contact with the magnetized cores in the center of the coils, and at the same time the magnetic circuit is closed, thereby generating a vigorous current, which is of longer or shorter duration, according to the time the two metals are in contact. A horseshoe magnet is not absolutely necessary, as, when the core of a straight bar magnet is touched, the effect is the same to the ear as if the magnetic circuit was completed. Touching with a magnet of opposite polarity to the core gives results similar to soft iron; but if the core be in contact with a similarly magnetized pole, no current whatever results. It is clear, therefore, that mere hammering of the one metal upon another will not generate currents. The core is also dumb when touched with copper, brass, etc. Soft iron, nickel, and the opposed pole of a magnet are the best touchers of a magnet. Of course, much depends upon the size and capacity, as also upon the quantity, size of wire, and the method of joining up the coils. Anything intervening between the soft iron and the magnetized core of the coils, which prevents direct contact between these two, detracts largely from results. On the other hand, by winding the legs of a penny magnet with a quarter of an ounce of No. 40 wire, and tapping the poles with its tiny armature, currents are sent, and signals are quite readable, through 5,000 ohms resistance.

From what has been said it is obvious that there are many ways in which this "touch of core" method of generating currents can be utilized; but conspicuous above all is its fitness for military telegraphy, in conjunction with the telephone as a receiver, as batteries are thus dispensed with.—*Electrical Review.*

THE ANTI-FAT CRAZE.

THERE is inconceivable folly in the fear of fatness. We do not for a moment deny that it is possible the organism may be too heavily packed with adipose tissue, and that the action of its several parts may be hampered by this encumbrance, while, as a whole, it is needlessly burdened; but this is a totally different matter from the fatness against which the fears of the multitude are for the most part unreasonably directed. There is not the least physiological connection between the accumulation of fat and fatty degeneration. As a matter of fact, what is known as "fatty degeneration" occurs more frequently in those who are lean than in those who are "fat" in a popular sense. It is therefore a misconception to suppose that fatness is in itself a disease. It only becomes morbid when, by mechanical pressure, fat impedes the functions of the organs, or by weight it unduly burdens the body so as to exhaust the strength or make too large a demand on the resources of force and vitality. Unfortunately, the true nature of the objections to fatness are not explained, and misconception is rather confirmed than removed by the prevailing mode of urging arguments against "fat" and in favor of remedies by which it is proposed to get rid of it. Practically speaking, it is idle to suppose that fatness can be certainly prevented by dieting. There are many ways of fat-making, and those persons who have a tendency to its production will make fat however they are fed—in truth, almost as rapidly on one class of diet as on another. There are idiosyncrasies which may in a limited number of instances be taken advantage of to check the tendency to form fat, but these specialties of chemico-nutritive function are by no means common; and, speaking generally, it must be said that, except by starving the body as a whole, fatness cannot be prevented. The exceptions to this rule are chiefly such as may be explained on the principle of a special tissue appetite. Thus, for example, a man whose muscular system has been healthily developed somewhat in excess of the other parts of his organism may have what might be called a muscular-tissue appetite of such voracity that it will, so to say, seize upon the bulk of the nutriment supplied to the blood, and make muscle regardless of what may be left for the nutrition of nerves, etc. Such a person will lose fat without growing thin, so far as muscle is concerned, by a mere reduction of diet, without reference to the kind of food cut off, so that the latter do not chance to be essential to muscle nutrition. In the same way, though with different results, a "nervous" person, in the popular sense—that is, an individual whose nervous system is in perpetual activity, working incessantly and feeding voraciously—may consume so much of the food supplied for the body as a whole that only nervous tissue is nourished, and the rest of the body languishes. This is an instance of growing thin while feeding well, and it is the converse of the process by which, in another class of persons, growth of muscle persists in spite of a reduced diet. There are, in this way, persons whose specialty it is to make adipose tissue, and they will wax fat even when muscles, nerves, and the higher organization are relatively in a condition approaching starvation. These and a score of other matters have to be taken into account when calculating the probabilities—or rather the improbabilities—of success in the endeavor to diminish the fatness of any individual by a system of dieting. As regards the use of drugs against fats, setting aside such obvious modes as robbing the blood of its proper nutriment by purging and nauseating, we do not believe it is practicable to prevent the formation of adipose tissue or even to promote an elimination of fat by the use of medicines, unless it be by correcting some error in the chemico-vital processes of the organic economy, to which a particular remedy may, as a temporary expedient in here and there a suitable case, be intelligently directed. Measures against fatness are, from the very necessities of the enterprise and the conditions under which it must be carried out in the great majority of instances, predestined to failure. It would save a deal of disappointment, and a great many incidental injuries to health might be avoided, if these facts could be more generally understood; and we think medical practitioners generally may be fairly asked to state and explain them.—*Lancet.*

THE DEFENSES OF PLANTS.

MOST of us regard the world of plant-life as a huge collection of beings which hover on the verge of existence, and at best only "vegetate," in place of living the free and active existence of the animal kingdom. This view of matters, however, would appear to represent opinions which are in a state of rapid dissolution, if recent science as well as research of tolerably advanced age are to be trusted. Persons learned in things biological tell us that plants are by no means the stereotyped units they have been regarded by popular philosophy. We hear of plants that feel, and of others which shrink on the slightest touch, and only expand their sensitive leaves after an interval has elapsed, and after the irritability of the living tissues has been appeased and mollified. We read of others which lay wary traps for insects, and which, imitating the *role* of the spider, capture, by aid of cunning contrivance, the unsuspicious fly. The Venus' fly-trap thus spreads open its leaf as

an inviting surface for insect visitation, and closes its frond upon the winged visitor which has touched the sensitive hairs that rise from the plant's foliage. Nor is this the whole story of plant sensitiveness. The Venus' fly-trap does not capture insects for amusement, but for use, and as a part of the business of its proletariat. It eats and, what is more, digests the fly it captures, and this by a process which, botanists tell us, closely resembles digestion in ourselves. In like manner the sundew of our bogs and marshes catches flies and eats them—the animal falling a victim to the snares and wiles of the plant. Then come the pitcher plants, which visitors to Kew must have noticed, if for no other reason than that the leaves are marvelously modified to form hollow appendages which give to the plants their popular name. Within these "pitchers," flies and other insects in a state of decay are to be found. The pitcher itself is a kind of insect trap. Down into its slimy depths slips the fly which alights on its smooth and treacherous margin. With wings bedraggled and wet, the insect creeps up from out its prison-house to the light of day, only to find that an array of spines pointing downward like a *chevaux-de-frise*, or a charge of fixed bayonets, impedes its course to the outer air. And so the fated insect falls back into the plant-pitcher, is speedily suffocated amid the fluid that receptacle contains, and adds its body to the decomposing material which previous victims have gone to provide. From this decaying solution—this literal insect soup—the pitcher-plant appears to draw much of its nutrition.

In respect, however, of the defenses which they present against foes and enemies of various kinds, many plants exhibit devices of no less ingenious nature than those by means of which they capture their food. In either respect we see how the vegetable world becomes lifted out of the rut of a dull, half and half vitality into the region of active life and labor. When plants grow old, as has well been pointed out, they tend to protect themselves by reason of the density and hardness of the parts they develop. Contrariwise, the young parts of plants, illustrating structures of more tender nature, are often found to be specially defended by prickles, spines, thorns and like contrivances. What, for example, are we to say to the defenses of the appropriately named "Wait-a-bit" thorn of Ethiopia, which grows spines of immense length, utterly impenetrable by man or beast? The lion himself does not venture to tackle this formidable plant. Each spine, sharp as bayonet, and as thick and effective, wounds and lacerates any living body which comes in contact with it. Nor does this curious plant stand alone in its special mode of defense. Grisebach, a noted botanical authority, tells us that all desert regions are distinguished by the high development of thorny defenses in their plants. Nature in such a case seems to run to spines and prickles, as if imitating in the merciless character of her plant-life the barren features of the surrounding land. There is, however, one noticeable point in connection with the growth of spiny defenses in plants. The thorns, as a rule, do not grow above the level commonly reached by animals which might crop the leaves for food. Plant development is conducted evidently on lines of strict economy. "Waste not, want not" is a maxim which finds a frequent reflex in the ways of vitality. Nearly related to these bayonet-like defenses are the stinging organs of plants. We have two species of nettles in this country, which blister the skin and cause pain and smarting when they are unwittingly touched. The urticating organs in the nettles and allied plants are simply modified hairs, similar in nature to those seen on most leaves. The hair is hardened somewhat, and pointed above. Below there is a mass of cells forming a gland which secretes a fluid of acrid and poisonous nature. When we grasp our nettle, we crush the hair and suffer no bad effects; but when we touch it lightly the hair is driven downward, the sharp point is broken off in the skin, and the acrid fluid is forced upward into the tissues, and produces therein the well-known inflammatory effects. The "survival of the fittest" is in one sense a grim commentary on the success of an ill habit, if we are to judge by the plentifulness of the nettle tribes among ourselves. But abroad these plants would appear to flourish with equal vigor and persistence. What is to be thought of the giant nettle of New South Wales, which may grow to a height of 120 or 140 feet, and which is provided with a poison fluid of proportionate virulence? Here the young leaves measure some 12 to 15 inches in breadth. Another Indian species produces in man, when its leaves are bruised and when the irritant fluid escapes, a copious flow of saliva, and gives likewise all the symptoms of a severe cold in the head, as well as fever and other untoward symptoms as the result of its sting. A Timor nettle is said to produce effects on man which last twelve months, so intense is the severity of its poison.

Passing over many cases of plant defense in which we find contrivances for repelling intruders on the vegetable domain, ranging in variety from glutinous secretions to bitter tastes and odors aromatic or disagreeable to birds and other plant visitors, we may find more noteworthy examples of curiosities in the way of the repulsion of enemies. Co-operation is a principle not unrepresented in plant existence. There is a parasitic plant of Sumatra, for instance, which has established singular relations with colonies of ants. The insects inhabit the tuber of the plant, which itself is a parasite on trees. Within this tuber the ants burrow to form their nests and winding passages. As these insects sting very severely, it becomes clear that animals will be chary of meddling with their plant host. An association of almost similar kind is seen in a well-known member of the acacia tribe. Here we find spines of large size borne on the stem and branches. Below, each of these thorns is hollowed out, and in the receptacle thus formed ants are found. There is not merely a leaning upon the insect for defense in such a case, but also a decided preparation for the comfort and habitation of the defenders in the shape of the hollow spines, and also in the form of a large gland which manufactures the nectar on which the ants subsist. In return for defense, the plant offers board and lodging to the insects, and provides a free breakfast table for their use. Since the days when a work on flowers and their unbidden guests was written, botanists have been enlarging our knowledge of the often quaint and marvelous ways in which plants, while inviting certain insects for purposes of fertilizing their flowers, protect themselves against invasion by other and undesirable insect guests. Ants are abhorred, so to speak, by the majority of plants. They steal the honey, but afford no benefit to the flowers in return. Hence, plant nature protects itself in this sense against the ants, as in another sense it invites these insects for protection. Thus in the teasel there are cups at the bases of the leaves, filled with water, and presenting impassable barriers to ants which may try to ascend the stem. In the pineapple leaves a similar arrangement is found. Sticky organs catch and kill ants, as in the "catch-fly," and the willow has slippery stalks to its flowers, which try to defeat any acrobatic impulses with which ants may be attacked or impelled. Yet the insect is sometimes equal to the task of circumventing the defenses of the plant. There is an Alpine variety of the monk's-hood which is fertilized by bumble-bees. But one bee, instead of legitimately taking the honey from the front of the flower, and of thus aiding the work of plant fertilization, actually bites a hole in the back of the flower, and abstracts the honey, without in any sense benefitting the plant. There is, however, another variety of this flower, which, having a bitter and acrid taste, is left unassailed by these insect thieves. The whole topic is full of interest to every lover of nature; and the subject is none the less interesting, because in so many ways it shows reflections of a prudence and wisdom that find their analogues in many of the contrivances wherewith man protects his own interests in the world of higher life.—*London Daily News.*

DR. OLIVER WENDELL HOLMES AT CAMBRIDGE UNIVERSITY.

ON June 17, in the presence of a large and enthusiastic assembly in the Senate House at Cambridge, the honorary degree of Doctor of Letters was conferred upon Dr. Oliver Wendell Holmes. The public orator in presenting Dr. Holmes to the Vice-Chancellor, characterized him as one who combined enthusiasm for science with distinction in literature, one who "Phœbo ante alios dilectus" had received more than one gift of Apollo, the gift of skill in the healing art as well as the gifts of eloquence and soul. In allusion to the death of Addison, of which that day was the anniversary, the orator said that the language of eulogy once applied to that writer might appropriately be transferred to Dr. Holmes: Haud ignobili poetæ, in oratione soluta contexenda summo artifici, censori morum gravi sane sed et perjucundo, levioribus in argumentis subridenti suaviter, res etiam serias lepore quodam suo contingenti." Addison, however, had died in the forty-seventh year of his age, whereas Dr. Holmes was nearly fifty when his fame as a writer burst out into a fresh brightness like that of the Indian summer—"ubi in ipso autumno novus refulget æstatis splendor." The orator concluded in these words: "Videor mihi vatem quendam canentem audivisse, illum cujus in corde æstas æterna floreret, non vocandum esse senem. Equidem juventutis perpetuæ fontem illum quem trans æquor Atlanticum Hispanorum nautæ frustra quærebant, nautam hunc feliciorem, non fabulosas inter insulas sed Academicæ juventutis in amore perpetuo, in amore mutuo, invenisse crediderim. Trans occidentis amplum illum sinum, levi phaselo vectus, diu naviget; nautili illius ritu, quem versibus tam pulchris descripsit, indies 'per ampliora ad altiora' tendat. Suam Academiam, per tot sæcula feliciter conservatam, intra paucos menses carmine sæculari iterum celebret, diuque superstes ipse exornet; nostræ denique Academiæ honoris causâ adscriptus, diu et nostrum et totius litterarum reipublicæ ad fructum floreat, vigeat, valeat, litterarum doctor, Oliver Wendell Holmes."—*Lancet.*

SCIENTIFIC EXPERTS AS WITNESSES.

LET us look at this question as it presents itself to men of science, alike to the chemist, the physicist, the mechanician, the geologist, the physician, and the microscopist, though certainly not to the astronomer, who is in no danger of being called, as such, to give his testimony. The expert occupies a totally anomalous position in court. Technically he is a mere witness; practically he is something between a witness and an advocate, sharing the responsibilities of both, but without the privileges of the latter. He has to instruct counsel before the trial and to prompt him during its course. But in cross-examination he is the more open to insult because the court does not see clearly how he arrives at his conclusions, and suspects whatever it does not understand. The late Dr. R. Angus Smith complained of being "contemptuously compelled to herd with thieves and scoundrels in a witness-box." He adds: "I have seen barristers speaking to a scientific witness in such a way as to show that to them a witness was always an inferior person." Surely, every person who has been present at a technical trial, or has had to appear as an expert in a poisoning, a patent, or an adulteration case, will be able to confirm this from his own observation and experience.

Now it may, perhaps, be cynically hinted that men of science should be willing to bear all this annoyance for the public good. But is it for the public good? In the first place, not a few of the most eminent men in every department of science distinctly and peremptorily refuse to be mixed up in any affair which may expose them to cross-examination. "I will investigate the matter, if you wish it, and will give you a report for your guidance, but only on the distinct understanding that I am not to enter the witness-box." Such in substance is the decision of not a few men of the highest reputation and the most sterling integrity. Certainly it is not for the interests of justice to render it impossible for such men to give the court the benefit of their knowledge.

Further, the spectacle of two men standing contradicting or seeming to contradict each other in the interest of their respective clients is a grave scandal. Men of the world are tempted to say that "science can lay but little claim to certainty, and is rather a mass of doubtful speculations than a body of demonstrable truth." To us, at least, there is nothing more saddening than to read the trial of a notorious poisoner, or the report of a great patent case, especially if taken along with the comments of the press and of society on these occasions.

Here, then, we see that our present mode of dealing with scientific evidence is found on all hands unsatisfactory. The outside public is scandalized; experts are indignant; the bench and the bar share this feeling, but unfortunately are disposed to blame the individual rather than condemn the system.

But we fear that this unanimity of dissatisfaction will vanish as soon as a remedy is seriously proposed. To that, however, we must come unless we are willing to dispense with scientific evidence altogether.

As it seems to us, the expert should be the adviser of the court, no longer acting in the interest of either party. Above all things, he must be exempt from cross-examination. His evidence, or rather his conclusions, should be given in writing, and accepted just as are the decisions of the bench on points of law.—*Chemical News.*

GIBRALTAR.

THE greatest fortress, from a strategical point of view, is the famous stronghold of Gibraltar. It occupies a rocky peninsula jutting out into the sea, about three miles long and three-quarters of a mile wide. One central rock rises to a height of 1,435 feet above the sea level. Its northern face is almost perpendicular, while its east side is full of tremendous precipices. On the south it terminates in what is called Europa Point. The west side is less steep than the east, and between its base and the sea is the narrow, almost level span on which the town of Gibraltar is built. The fortress is considered impregnable to military assault. The regular garrison in time of peace numbers about 7,000.

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